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THE CAPE-TO-CAIRO RAILWAY.

By John Hartley Knight.

ASH-PIT AND TANK, MAFEKING.

"APT alliteration," quite as much as the magnetic personality of Mr. Cecil Rhodes, has popularised the Cape-to-Cairo railway scheme. There is much in a name. To countless thousands of English-speaking people there is something strangely fascinating in the phrase "Cape to Cairo"—far more so, maybe, than in any similar alliterative example, such as "London to Liverpool" or "New York to Yokohama." And the fascination is due not so much, perhaps, to the mere alliteration as to the vast extent of territory, mystic, wonderful, which the phrase embraces. From Cape Town to Cairo! The imagination reels at the tremendous prospect opened up by the phrase, and at the apparently insuperable difficulties confronting those who would dare attempt to annihilate space and bring the searchlight of civilization to bear upon the savagery and ignorance of what even now is still a very Dark Continent. On the other hand, five thousand odd miles—the sum of the distance separating Cape Town from Cairo—are as nothing to the resourceful railway engineer, and

It is heartily to be hoped that the prospects of peace in South Africa, apparent as this issue goes to press, may be fully realised. In any event, the close of the war is certain to be followed by an energetic opening up of the country by the pushing of various develop-

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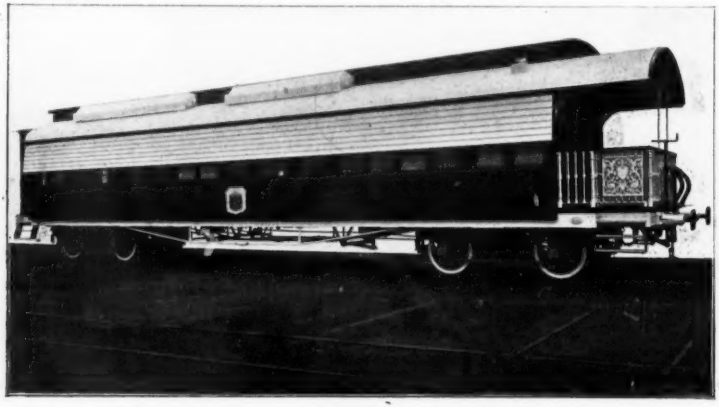
one marvels not so much at the vastness of Mr. Rhodes' scheme as at the fact that its conception should have been so long in the being. Five or six years ago the "man in the street" knew nothing, and cared less, about the matter. Nowadays it fills the popular mind and its



A SALOON CARRIAGE, BECHUANALAND RAILWAY.

daring is discussed on every side. Mr. Rhodes is credited with its conception—yet it is by no means certain that this should be so. The Cape-to-Cairo scheme, as such, was of slow growth. In 1879 some such scheme possessed the fertile mind of Sir James (then Mr.) Sivewright, then superintendent of telegraphs to the Cape Government. But his was a telegraph scheme pure and simple. In 1888, Sir Charles Metcalfe, Bart., the well-known engineer, conceived the idea of calling the then projected Bechuanaland railway the "Central African Trunk Line"—thus clearly foreshadowing the Cape-to-Cairo notion. In 1891 that instinctive writer, Mr. E. P. Mathers, was prophetically moved to inscribe on the cover of his book "Zambesia" the injunction to prospective railway travelers to "Book from Cape Town to Cairo via the Victoria Falls." Two years later we find the *Times*, in a leading article, discussing the proposed Bechuanaland line and

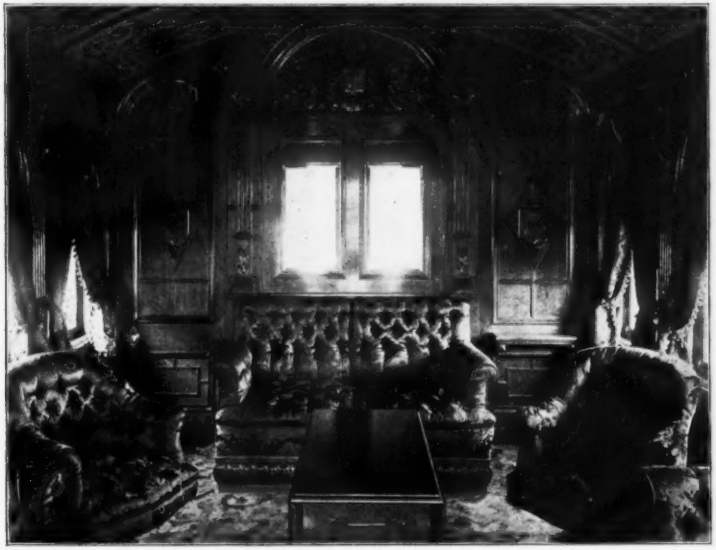
ment projects, of which the Cape-to-Cairo Railway is the most comprehensive and most magnetic.

Former articles in THE ENGINEERING MAGAZINE treating other phases of the movement have been:

The Transvaal Mines and the Boer Government. Dr. F. H. Hatch. Aug., 1899.
South African Questions from an Engineering Standpoint. Albert Williams, Jr. Dec., 1899.
John Hays Hammond on the South African Situation. Charles Buxton Going. Jan., 1900.
The Economic Conquest of Africa. H. G. Prout. Feb., 1900.
Gold Mining Prospects in Rhodesia. R. R. Mabson. Mar., 1900.

observing that the approval of the Government to the same "brings appreciably nearer the accomplishment of the aim of linking the British possessions of South Africa together from the Cape to the Zambesi, which has been the acknowledged goal of Mr. Rhodes' South African policy." Here we are distinctly informed that the Zambesi—not Cairo—was Mr. Rhodes' goal. The extension to Egypt was apparently not thought of by the South African Colossus until 1892—and only then, it would appear, in association with a telegraph scheme. Some time elapsed before the phrase "caught on" with the public, and to-day it is more popular than ever. Little Englanders may sneer at it and the Labouchères of the press may decry it as being impracticable, unprofitable, and useless. But the fact remains that the man in the street loudly approves it. Why? Because, in the first place, "Cape to Cairo" is irresistible as a phrase and, in the second, because in his heart of hearts he really and truly thinks there is "something in it."

The first stage of the Cape-to-Cairo line was completed long before Mr. Rhodes' name became linked with the phrase. This was as far back as 1859, six years after Mr. Rhodes was born, when the first railway in Southern Africa was begun between Cape Town and the little town of Wellington—a distance of 58 miles! Cairo was not the



INTERIOR OF SALOON CARRIAGE, BECHUANALAND RAILWAY

grand objective in those days. It is interesting to recall that the first sod of the line in question was turned by that great statesman, the late Sir George Grey, then Governor of Cape Colony. The line was constructed by an English company, and like many similar undertakings it cost more than the estimated amount—nearly half-a-million—to construct. The discovery of diamonds in Griqualand west, in 1867, gave the first great impetus to railway construction in the sub-continent. In 1872 the line was extended another sixty miles or so to Worcester, at a cost of £266,000, the money being raised in Europe. The chief engineering difficulties of the first great link in the Cape-Cairo line occur in the first hundred miles, in the mountainous and picturesque region known as Hex River, where the line climbs to an aititude of 3,588 feet. For a distance of more than twenty miles hereabouts the gradients are 1 in 40 and 1 in 45, with curves of five chains radius. Extensive rock cuttings and precipitous embankments are the characteristics of this section of the Cape railway. From Worcester onwards—passing Matjesfontein, Kimberley, and Vryburg (the last named being 774 miles from Cape Town) the line runs on comparatively smooth ground and through what is known as the Karoo, the praises of which have been so eloquently sung by the gifted authoress, Olive Schreiner. In 1874 railway construction on a large scale was resolved upon at the Cape, and ere long the iron horse—whose destination a later generation is resolved shall be Cairo—was well on its way to Kimberley. It would be impossible within the compass of this article to do anything like justice to the difficulties and disappointments which beset the pioneers of the Cape-to-Cairo line. Suffice it to say that on November 28th, 1885, the first train from Cape Town steamed into Kimberley—to the unspeakable gladness of the inhabitants. Another five years were to elapse before the 127 miles separat-

TRACK LAYING ON THE RHODESIAN RAILWAYS.

ON THE ZAMBESI.

ing Kimberley from Vryburg were metalled—not, however, that the line actually took all that time to construct. This brings us down to 1890—a year after the incorporation by Royal Charter of the British South Africa Company, and three years after the world had been startled by the discovery of the auriferous wealth of the Witwatersrand. Mr. W. T. Stead once very happily observed that, but for Mr. Rhodes, the Cape-to-Cairo line would have got itself built in sections and it would never have been discovered that it was a Cape-to-Cairo line until the last gap had been bridged and the trains were actually running. There is considerable truth in this. Although we have evidence that the Cape-Cairo idea was foreshadowed by others than Mr. Rhodes, yet it was reserved for him to, as it were, crystallise the idea and fire the fancy of his fellowmen with a seemingly impossible and daring project. Perhaps it was in 1890—the year of Mr. Rhodes' first premiership at the Cape—that the Cape-Cairo scheme began to be talked about. For three years, however, the iron horse remained stabled at Vryburg; and in 1893, the Bechuanaland Railway Company —now known as Rhodesia Railways, Limited—was formed for the purpose of constructing and working a railway from Vryburg to Mafeking and thence northward towards the River Zambesi—not, be it observed, merely to Palapye or Bulawayo, but right away north to the Zambesi. The contractors of the company were Messrs. Pauling & Co., Ltd. (who had built the line from Kimberley to Vryburg) and

the engineers were Sir Charles Metcalfe and Sir Douglas Fox. The gauge was to be as on the Cape line, viz., 3 feet 6 inches. The British South Africa Company advanced the money required for the construction of the line, taking 6 per cent. debentures issued by the railway company, which were afterwards exchanged for an equivalent amount of 5 per cent. mortgage debentures or debenture stock. The contract price per mile—90½ miles altogether—was £2,575. The section to Mafeking was opened for traffic in October, 1894, and the net earnings for the first ten months were equal to 4 per cent. per annum on the cost of the section.

A word at this juncture as to the country in which the second half of the Cape-Cairo line is situate. It is of the same level character as distinguishes, as we have said, the country from Worcester in the Cape Colony to Vryburg. "The whole country," to quote Sir Henry M. Stanley's description of the journey to Bulawayo, "seems to have

ENGINE SHED, MAFEKING.

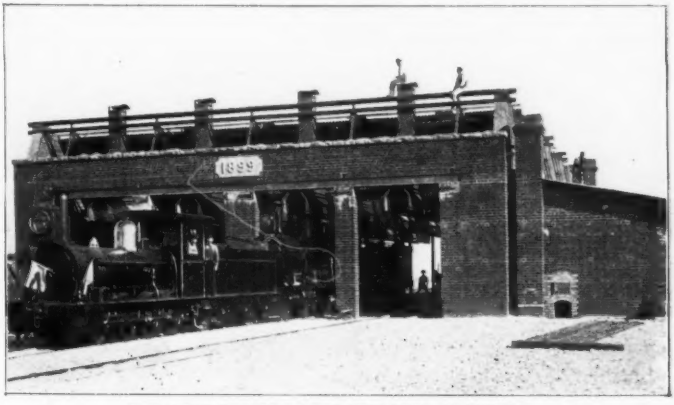
TURNTABLE, MAFEKING.

been created for railway making. It offers as few difficulties as the London Embankment. Hyde Park is extremely uneven compared with it." For nearly a thousand miles, the distinguished traveler goes on to tell us, the railway sleepers have been laid at intervals of 30 inches on the natural face of the land; the rails have been laid across these and connected together; the native navvies have scraped a little soil together, sufficient to cover the steel sleepers, and the iron road was thus ready for traffic. The scenery of Bechuanaland, which to a man accustomed to green fields and flowing rivers would appear a dry and waterless region, found much favour in the experienced eyes of Sir Henry Stanley, who tells us that he has seen nothing between the immediate neighbourhood of the Missouri River and the Rocky Mountains to surpass it; and he adds that the prairies of Nebraska, of Colorado, and Kansas—as he had seen them in their uninhabited state—are inferior in appearance to these "richly ochreous" plains.

The Bechuanaland Railway Company had no intention of letting the grass grow under their feet. The Mafeking extension was no sooner completed than the contractors started in earnest on the next

BALLASTING THE ROAD.

section towards Cairo, and before the end of 1894 the line to Gaberones, Palapye, and Bulawayo was well under way. The line to Gaberones—110½ miles—was opened in July, 1895; and two years later the whole section to Bulawayo was triumphantly completed. From Cape Town to Bulawayo is 1,360 miles. The inability of the Cape Government to transport material quickly helped to retard construction, and Bulawayo became so impatient to see the iron horse that Mr. Rhodes was induced to offer the contractors an extra £200 per mile to lay a mile of metal a day. The result was that the "last lap" was so hastily laid that, with the first heavy rains, the contractors had to face



THE FIRST ENGINE IN THE NEW SHED, MAFEKING.

STATION YARD AT BULAWAYO.

some serious wash-aways. All that, however, was subsequently remedied, and when once the trains were able to run into Bulawayo the contractors went back over the line and carefully completed the works in accordance with their contract. Thereupon the railway company became entitled to an annual subsidy for a period of years from the Imperial Government and the British South Africa Company, and the company are now subsidised to the extent of £30,000 per annum.

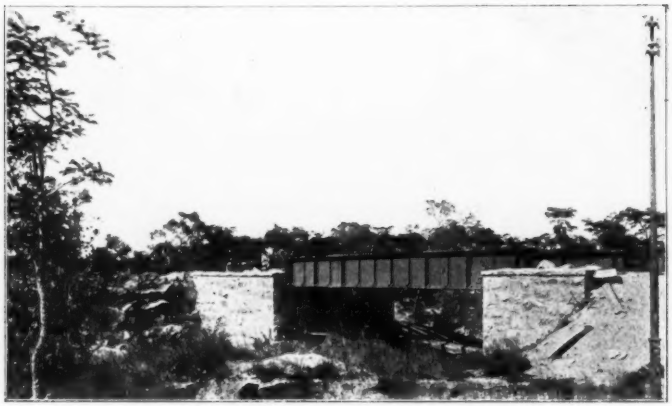
November 4, 1897, was a very great day in the history of Bula-

THE FIRST TRAIN INTO BULAWAYO.

wayo. On that day a number of the leading men of South Africa, and some distinguished visitors from England, foregathered in the town to celebrate the local arrival of the iron horse. Mr. Rhodes was ill with fever and could not be present; but he was not forgotten. Sir Alfred Milner, the High Commissioner, at a banquet given on the occasion, paid a high tribute to the foresight and energy of Mr. Rhodes, and said that even his bitterest enemies would admit his title to a place of honour that night, for he was not only managing director of the line, but prime mover in its construction. "Few events of the

TEMPORARY CROSSING OF THE SHASHI RIVER, THE BOUNDARY BETWEEN MATABELELAND AND THE BECHUANALAND PROTECTORATE.

century," wrote Sir Henry Stanley, "surpass it in interest and importance"—marking, as it did, "the conclusion of an audacious enterprise." Meanwhile, Mr. Rhodes' twin scheme—the laying of a telegraph line from north to south—had made even greater progress. A visit to Cairo in 1873 convinced the right honourable gentleman that it was impossible, then, to advance his project at that end of the continent. The Mahdi could not be "squared," Mr. Rhodes found; he was an insuperable difficulty. The work must therefore be prosecuted from the south. The scheme had long been carefully thought out and Mr. Rhodes threw himself into its execution with characteristic vigour. The telegraph line runs from Umtali, in Mashonaland, to Tete,

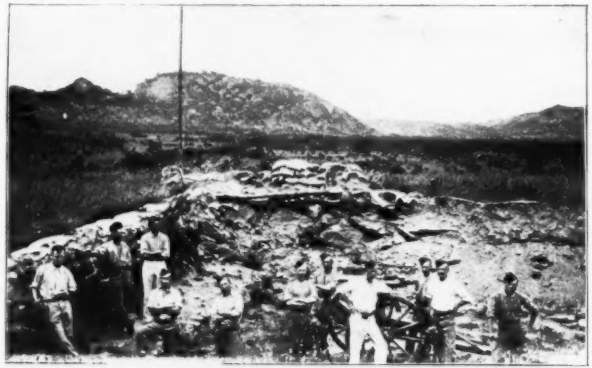


A 50-FOOT PLATE-GIRDER BRIDGE.

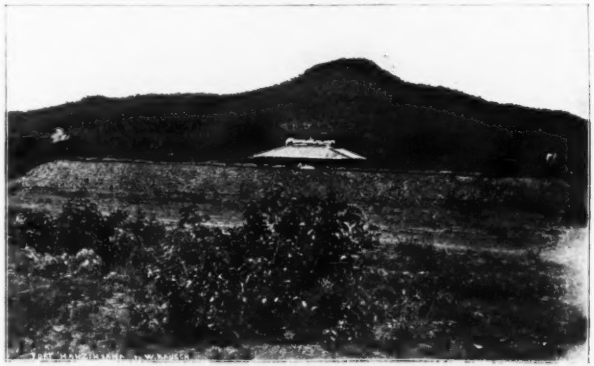
thence it goes in an easterly direction to Blantyre in British Central Africa, from Blantyre to Zomba, and thence to the western shore of Lake Nyassa. From Karonga the line is completed to Abercorn, at the south end of Lake Tanganyika; and by agreement with the German Government, the line will be carried through German East Africa to Uganda and so northwards, to connect with the line at Khartum. The authorised capital of the African Trans-Continental Telegraph Company is £300,000, in £1 shares, of which £170,320 has been subscribed and called up.

MACLOUTSIE BRIDGE. TWO SPANS OF ONE HUNDRED FEET EACH.

The Macloutsie is the first large stream south of the Shashi. Both are tributaries of the Limpopo.



Fort Umlugulu, on the Bulawayo-Pretoria Road.



Fort Manzinyama, about 30 Miles Southeast of Bulawayo.

Cumming's Store, where Gifford Had a Fight with Matabele.

Fort Halsted.

MILITARY OUTPOSTS IN THE TERRITORY OPENED UP BY THE CAPE-TO-CAIRO ROAD.

But to return to the railway. All the world knows how, in the early part of 1899, Mr. Cecil Rhodes came to England for the express purpose of getting the Imperial Government to assist him in extending the line from Bulawayo to Lake Tanganyika—roughly 800 miles. The Government hemmed and hawed for so long a time that Mr. Rhodes looked elsewhere for the financial help he needed—and found it. The Rhodesian Mining Companies subscribed £500,000 and the British South Africa Company guaranteed £3,000,000, the money being raised by means of 4 per cent. debentures, in instalments of £600,000 over a period of five years. Just before this happy issue out of his financial afflictions Mr. Rhodes visited Berlin to seek the sympathies of the German Government. His reception by the Kaiser and his people was extremely cordial, and before he left the German capital he had practically arranged that his telegraph and railway should both run through German East Africa. Mr. Rhodes went to Berlin with a concession in his pocket to take his lines through Belgian territory, but he preferred the German route. The section of the railway line to pass through German territory will represent a seventh of the whole line. Both the railway and telegraph will be constructed with German capital, although, of course, English capitalists will participate. There are two important features in the Anglo-German agreement. One is that the British South Africa Company binds itself not to continue its

AN ENGINE IN THE YARDS AT BULAWAYO.

railways to the west coast of Africa from the territories of Rhodesia or Bechuanaland south of the 14th degree of latitude, save from a point on the Anglo-German frontier to be determined by special agreement with the German Government. Further, the British South Africa Company is bound not to construct a railway north of the 14th

degree of latitude from the above-mentioned territories to the West African coast until a railway line has been constructed south of that degree of latitude, through German South-West Africa. The next great link in the Cape-Cairo chain embraces what is perhaps at once the most interesting and richest portion of the route. The first half

ANCIENT RUINS IN RHODESIA.

from Bulawayo to Zumbo, on the Zambesi—passes through the gold districts of Mafungabusi and Lomagundi and also skirts the Sengwe coal area. Sir Charles Metcalfe, who recently surveyed this part of the country, gives some interesting details of its geographical features. The country, he says, is a high level for the first 150 miles from Gwelo, the height being about 4,000 feet; when within 50 miles of the Zambesi, the surveying party came upon a high range of mountains 20 miles in breadth and from 3,000 to 4,000 feet in height, consisting of innumerable quartz reefs and slates almost on edge. From this range there is an abrupt drop of 1,200 feet to the level of the country near the Zambesi, which is some 1,800 feet above the sea. The Zambesi just above Kariba Gorge—through which, in all probability, the railway will pass—is about a quarter of a mile in width, and at the junction of the Sanyati River it narrows to the passage called Kariba Gorge, which for a mile in length does not exceed fifty yards in width. This section of the line passes within easy distance of the magnificent Victoria Falls—the Niagara of Rhodesia—to say nothing of many interesting and ancient ruins, the origin of which has so puzzled the archæologist. From the Zambesi River the line will pass to the great Lake Tanganyika, through country which is still in a great degree *terra incognita* but which, thanks to the splendid impulse given by Mr.

Rhodes, is rapidly being opened up to trade. The line will pass to the east of Lake Bangweolo, through magnificent country, good for cattle and especially productive of india-rubber, which is indigenous. Minerals, such as copper, are known to exist in this region. As far as possible all swamps and low-lying districts where fever is prevalent will be avoided.

Some interesting and graphic details of the Ruanda country, between Lakes Victoria and Tanganyika, are given by Mr. E. S. Grogan, who recently returned thence, and who is probably the first white man who has travelled through Africa from the Cape to Cairo. Mr. Grogan found many active volcanoes in this region, one of which had

A WAR DANCE.

existed for only two years, and which covered an area of between thirty and forty miles. Though there was no water in this country—the ground being too porous—it was very densely populated, the natives tapping water from the banana palms. Lava streams abound; and the whole country is overrun by a nomadic tribe of cannibals.

Dr. Emil Holub, the African explorer and scientist, in discussing the proposed route with the *Morning Post* interviewer last year, said it appeared to him that Mr. Rhodes did not take the conditions of climate sufficiently into consideration. The Marotse country should be avoided. The Marotses were a fierce, warlike people and might give

ROADSIDE STORE ABOUT 12 MILES FROM GWELO.

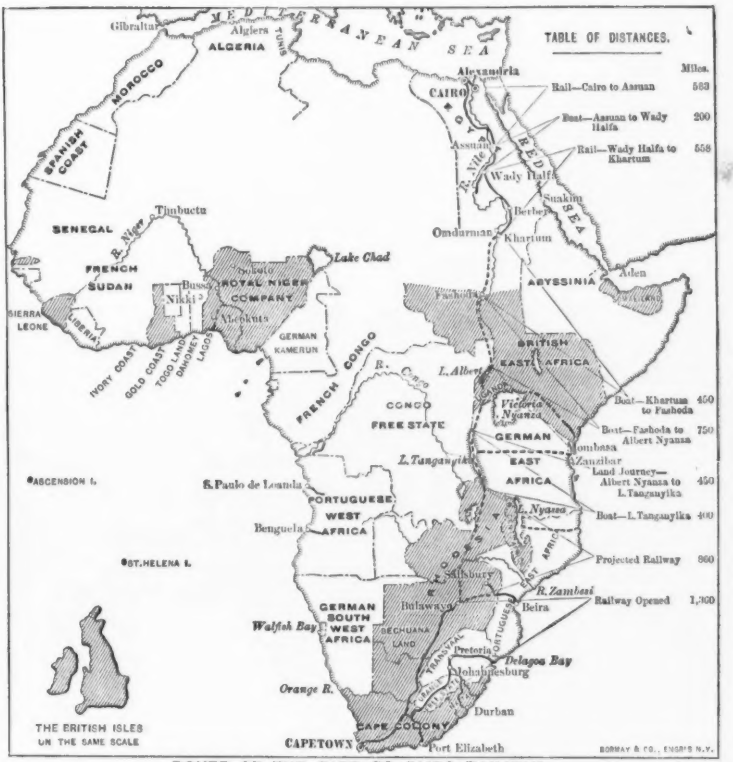
trouble. The natives died like flies of malaria in this country, whereas by edging further to the east, where the country was comparatively healthy, that would not be the case. On the other hand, the many rivers and the mountainous nature of the land had, no doubt, determined Mr. Rhodes, owing to the great difficulties of engineering, to abandon any attempt so far to the east. Still, he thought that in the end it would prove the surest and most economical route to pursue. Dr. Holub added that neither the Beira railway from the east nor the Congo railway from the west could ever compete with Mr. Rhodes' great line, which must be in the future the great carrying route for Africa. "Trade would always by preference go to the Nile; the Nile was the great waterway to civilisation." Directly the Zambesi is crossed towards the north one begins to ascend to the crest of the watershed between the Zambesi and the Congo, which is "but little higher than the highest grassy ridge in the neighbourhood of Salisbury. From thence," says Stanley, "a gradual descent is made to reach the central depression of the Congo basin." Northwards of the

VIEW OF SALISBURY FROM THE KOPJE.

Congo watershed are again "the average altitudes of grassy ridges of South Africa," and then begins a descent into the basin of the Tchad Lake, and from thence to the Mediterranean the same system of great land waves, rolling and subsiding, continues. As to native labour, Mr. Rhodes should find no lack of it. He will probably get all he wants from Barotseland in Northern Rhodesia, the king of which country is said to be a somewhat enlightened monarch with a leaning towards the methods of civilisation. In German East Africa the line will probably pass through Tabora, and thus connect with the railway

LAUNCHING GIRDERS OVER THE KHAMI RIVER, A FEEDER OF THE ZAMBESI.
It is crossed near its head, about 15 miles southwest of Bulawayo.

which it is proposed to construct from that town in an almost due easterly direction to the coast (Zanzibar). British territory is gained once more on the borders of Uganda, which is not so quiet a region as could be wished, but which is rapidly "settling down" under the firm sway of its new rulers. Here, the line will eventually connect with the railway now being constructed from Mombasa on the coast to the north of Zanzibar. Thanks to Lord Kitchener, whose splendid service to the Cape-Cairo scheme calls for the most generous recognition, Mr. Rhodes today has no Mahdi to fear—or to "square"—and the recent death of the Khalifa and the capture of Osman Digna have materially assisted in paving the way towards the realisation of the dreams of the Cape Colossus. Long before Mr. Rhodes' workmen, creeping up from the south, have reached the southern end of Lake Tanganyika,



ROUTE OF THE CAPE TO CAIRO RAILWAY.

the chances are that the workers from the north will have joined hands and metals with the German railway engineers on the southern border of Uganda. Before this, however, it is just possible that Menelik, of Abyssinia, who is reported to be a particularly wily individual, may have to be reckoned with—but Mr. Rhodes will doubtless be quite equal to the task. The Mahdi was admittedly too difficult a nut even for Mr. Rhodes to crack, but from Menelik no really serious opposition need be apprehended.

It is interesting to recall that the other day, when the railway had reached Bulawayo on the 20th parallel of south latitude, the railway from Cairo was at the Third Cataract, on the 20th parallel of north latitude. Since then the railway from the north has made very considerable progress, and one can now travel from Cairo to Khartum

almost as easily and safely as from London to Brindisi. A few years ago it was pointed out by an authority in a letter to the *Times* that, in the old days when the Mahdi flourished, a journey to Lake Albert with arms and baggage, might be counted thus: Cairo via Suez to Suakim, steamer, six days; Suakim to Berber, camel, ten days; Berber to Redjaf, steamer, ten days; Redjaf to Kiri, boat, one day; Kiri to Dufli, road and porters, five days; Dufli to Kavalli, steamer, three days—in all thirty-five days, or five weeks, from Cairo to within sight of Stanley's Ruwenzori, the mystic Mountains of the Moon. It has taken thirty-eight years to construct the first link in the Cape-Cairo chain from Cape Town to Bulawayo—1,360 miles—but it will probably take considerably less than half that time to metal the remaining 4,000 or so miles from Bulawayo onwards. Indeed, Mr. Rhodes may very reasonably expect to live long enough to see the accomplishment of his great scheme. In twenty years' time, it is safe to prophesy, railway development in Africa will have made enormous strides—and the many important branch lines to connect with the Cape-Cairo trunk will have been constructed or be near completion. In the south the line from Johannesburg will have joined that at Bulawayo; Bulawayo, again, will be connected with a line running right across country to Walfisch Bay in German West Africa. In Central Africa, the trunk line will connect with German and British lines running to the east coast; and it is only reasonable to suppose that by that time a line or lines through Belgian territory will connect or be in close touch with the Cape-to-Cairo route. And that the trunk line will be a paying concern there is no reason to doubt. In the Rhodesian section already built the returns have advanced by leaps and bounds. For the first 13 months to October 31st, 1895, the net earnings amounted to £11,877; for the 12 months, ended October 31st, 1896, £38,043; for the 12 months, ended October 31st, 1897, £66,767, and for the 12 months, ended October, 1898, £99,290. These returns, it should be added, do not include the subsidies of £20,000 from the Imperial Government and £10,000 from the British South Africa Company. So far the profits have been utilised for the betterment of the line, but the time is not far distant when the shareholders will be pocketing handsome dividends. The engineering difficulties of the Cape-to-Cairo line are considerable, but not insuperable whilst labour is cheap and plentiful; so that, with Mr. Rhodes at the head to "push the thing along," there is every prospect of the scheme, vast as it is, being successfully accomplished, and that at no very distant date.

The Editor acknowledges the courtesy of the British South Africa Company in lending the photographs used in illustrating this article.

A COMPARISON OF THE ISTHMIAN CANAL PROJECTS.

By George A. Burt.

THE most important engineering problem in the world is the proposed piercing of the American Isthmus by an interoceanic canal. From the American side, the Nicaragua Canal Company has studied the facilities offered by the San Juan and Lake Nicaragua route, and has matured a project with many complications and unprecedented constructions necessitated by the topographical difficulties of its emplacement. The company failed to float securities and appealed to the United States Government to endorse bonds and otherwise go into partnership. Because of agitation in this direction, Congress had the Ludlow commission appointed to examine the route proposed by the company. In due course the commission reported in 1895 substantially that they believed the canal feasible at double the company's estimated cost, but they recommended extensive surveys, now in progress, to develop lacking information and establish more definitely the technical basis.

The French Panama canal, organized by de Lesseps in 1879 as a commercial company, floated securities for vast sums and began cutting a sea-level canal at Panama, winding up in 1889 out of funds. Since that time work and machinery has been well cared for and a considerable amount of excavation has been done on the summit cut, but in general the idea has been to maintain the *status quo* pending formation of a new company. In spite of the very substantial results accomplished by the French company at Panama, in the United States an interoceanic canal is supposed to mean only the Nicaragua canal. Little information exists regarding Panama—little more than a hazy and hugely mistaken idea that the canal has been abandoned as an impossible enterprise. The Atlantic termini of these two canals are about the same distance from New York, and about 300 miles apart.

It seems only too probable that, before this issue of THE ENGINEERING MAGAZINE appears, the United States will have committed the egregious folly of blindly endorsing the Nicaragua canal scheme, although every expert recommendation has been to the effect that such studies as the Walker commission are now concluding are absolutely essential to an intelligent judgment. If the Nicaragua route is the best, its advocates can fear nothing from the report of this commission. This comparative review is presented in hope that there may still be opportunity for sober sense to assert itself and await the evidence before giving the verdict. Since Mr. Burt's article was written, a new project is in existence for Panama, making many improvements in details. The Nicaragua plan may also be modified by recommendations of later commissions, but the general comparison is not materially affected. Further reference to the subject will be found on page 107.—THE EDITORS.

Each route is a little shorter for certain ports than the other, but for traffic as a whole it is evident that such difference in sailing distances can be of little moment. The whole decision, then, turns on the practical points of cheapness of cost and maintenance and flexibility of operation, and it is on these points that I propose to compare the two canal routes. It is, of course, necessary to compare canals of the same size in their wet cross sections, calculate quantities at the same price for similar materials, and in general compare on a uniform basis.

For the Nicaragua route the project estimated by the Ludlow commission is taken as a basis, involving:

Creation of harbors in two oceans;

Canal in excavation on both slopes ascending to summit level by four locks;

Damming the San Juan River at Ochoa by a rock-fill dam and converting it into slackwater and part of the summit level, at a minimum elevation of 110 feet above sea level.

For Panama, project of an artificial summit level formed by damming the Chagres River at Bohio to an elevation of 100 feet above the sea level, and descending to sea-level canal on either slope by a group of three locks.* This project has been thoroughly surveyed by the N. B. Wyse commission; additions have been made to conform it to the Nicaragua project.

Terminal Dams: The construction of these two canals is peculiar in the respect that both are dependent upon the feasibility of constructing rock-fill dams of great magnitude. Dams are to be formed by dumping large rocks from cableways, allowing the stream to scour between, to distribute them, and to settle them to a firm bed in the sand and clay beneath. The voids between the large stone are, at the same time, filled with smaller stone, and these voids in time are to become sealed by sand and clay. Back of the rock fill is to be dumped a heavy bank of clay. These dams are to be subjected to the flow of their rivers during construction, but to be raised to such permanent height as never thereafter to act as weirs. The length of crest line is about the same, but the Nicaragua Ochoa dam is 62 feet between water levels and the Bohio 90 feet.* In both cases their bases are supposed to settle many feet below the river bottoms by the scouring action of the water. The Bohio dam is higher* than Ochoa, but has the advantage of having its side slopes on solid rock. At Ochoa they are clay, and extensive abutments must be made to pre-

* These points are materially modified and improved in the plan now presented by the *Comité Technique*. The Bohio dam is much lower, while a second dam at Alhajuela regulates the upper Chagres.—THE EDITORS.

vent scour around the ends. At Bohio, rock hills surround the site, affording cheap quarries for stone, while at Ochoa it must be obtained fifteen miles away. The quantities at Bohio are larger, but the construction as a whole is cheaper, mainly by reason of the absence of necessity of devices for controlling floods during construction. The respective maximum floods estimated are 150,000 cu. ft. per second at Ochoa, and 70,000 ft. at Bohio. Whatever question there may be in regard to such dams, it is the same in either case; in spite of the greater height, the Bohio is certainly equal, if not superior, to Ochoa in conditions as a whole.

Water Supply: At Nicaragua there is no question as to ample water, the trouble being that its excess flow in floods is difficult to keep within such limits as not to drown property around the lake front. At Panama the summit level of 35 square miles in area is much more restricted. The canal in excavation in the summit cut is 33 feet deep below the spillway elevation of 100 feet. There is, in consequence, 3 feet storage over the summit level to be exhausted before the regular 30 feet depth will be interfered with. The minimum low-water discharge of the Chagres River at Gamboa, some 14 miles above Bohio, has been measured for years and is equal to about 950 cubic feet per second. Five considerable streams enter in the 14 miles and I would assume that at Bohio there would be a minimum of not less than 1,100 cubic feet per second.

The area of the summit lake is 975,444,000 square feet. Storage 3 feet deep gives, therefore, 2,927,232,000 cubic feet. Water for one lockage 650 x 80 x 36 feet requires 1,872,000 cubic feet. Assuming that each vessel will require on average 1½ lockfuls for passage, this should be increased to 2,808,000 cubic feet. Evaporation ¼ inch per day over surface would amount to 20,327,000 cubic feet. The low-water flow of the Chagres River per day is 95,040,000 cubic feet. Assuming that the maximum traffic figured for Nicaragua should be an average—there would be:

Thirty-two vessels locked per day, requiring—	89,856,000 cubic feet
Evaporation, as above.....	20,327,000 cubic feet
Consumption of water per day.....	110,183,000 cubic feet
Against this there is low water supply.....	95,040,000 cubic feet
To be supplied from storage per day.....	15,143,000 cubic feet

The storage between contours 97 and 100 is figured, as stated above, at 2,927,232,000 cu. ft., sufficient to meet the above de-

ficiency for nearly 200 days with permanency of extreme low-water flow for that time. The above calculation neglects leakage; on the other hand, it assumes the absolutely Utopian supposition that thirty-two vessels would be an average daily transit, and the equally impossible condition that extreme low water could continue for that length of time. The small Pedro Miguel dam will be tight by construction, and the Bohio must be made so by thoroughly compacting the earth lining. There then remains to be considered the leakage past lock gates. This is an indefinite amount, but is not necessarily large. There is ample margin for this and all other contingencies. But it is obligatory to make the Bohio dam tight, as must also be done at Ochoa, for similar reasons. It is an easy matter, with some extra expense, to double or treble this storage by increasing the elevations of spillways and cutting the summit lower. Lateral canals extend from Bohio to the sea, to receive spillway discharges and side streams and keep them from the canal.

Culebra and the Chagres: It was formerly said that the sliding strata at Culebra and the regulation of the Chagres River were two things at Panama impossible of control. The sliding material at Culebra* is a bed of fine clay, very absorbent of water and plastic in that condition. It is nowhere more than 30 feet thick; 1,300,000 cubic yards will cover the whole deposit, and the removal of that quantity figures in the estimate. In the present project the Chagres is received into the lake and offers no difficulties. It is the same problem that must be met at Nicaragua, with a flood discharge there doubly as great, and with the controlling necessity that regulation must be so efficient as never to raise the level of Lake Nicaragua† more than 3 feet above the determined artificial level. At Panama the only limit to permissive rise would be that of convenience in locks and spillways.

Supporting Structures for Summit Level at Nicaragua: I find, in a cursory examination of the Ludlow report, mention of one hundred and thirty-two such structures in the form of locks, dams, weirs, sluiceways and embankments. The worst case is the San Francisco division, and for that the Ludlow report is here quoted: "The total number of embankments is no less than sixty-seven, with a total crest

* It must not be forgotten that the proposed central-divide cut on the Nicaragua route is three miles long and has a maximum depth of 328 feet, and that borings have revealed "rock more or less decomposed" at great depths below the surface "which may crush and allow the sounder rock above to fall."—THE EDITORS.

† Prof. Heilprin has recently called attention to remarkable differences in various determinations of the level of Lake Nicaragua. He concludes that the level is inconstant, and the oscillations possibly connected with volcanic disturbance to which the region is subject. Information on this vital point is sadly incomplete.—THE EDITORS.

length of 6 miles. The largest of these is the San Francisco, with a crest length of 1.2 miles, an extreme height above the river of 85 feet. There are five others—from 1,040 feet, with greatest height of 60 feet, to 1,840 feet, with height of 79 feet. These heights are measured from the surface of ground and do not include foundations. Borings in the beds of the Danta and Nicholson sank through 30 feet of soft mud to clay. There are at least four of these dams that will have a height considerably over 100 feet."

There are to be clay banks built under a rainfall of 25 feet per annum yearly, and with material brought from a distance. Their construction offers enormous difficulties, and their maintenance is an equally grave question. The locks, spillways, and every form of construction have in nearly every case to be founded on clay. It cannot be denied that this condition is a very serious construction difficulty. Each one of these structures might be the place of damage from undercutting water, destroying the use of the canal for a long time.

At Panama there are two groups of structures to support the summit level.* These groups consist in each case of the terminal dam, the lock, and spillways. Everything is on rock foundation except the Bohio dam, and that is better situated than the Ochoa. There can be no question as to the greater relative simplicity of the technical problem at Panama.

Locks: At Nicaragua the locks are eight in number, at separate locations, with intermediate ponds. These locks require each vessel that passes the canal to make eight separate manœuvres of slowing down and warping in, with eight chances of fouling from misdirection and drift of the wind. At Panama six locks are grouped in two emplacements.* Only two entrance movements are required for a transit of the canal. It is self-evident that this is quicker, easier, and more advantageous in every way. The topography permits this grouping of locks at Panama, but it is impossible at Nicaragua. The objection is evident that with single-track locks the rapidity of lockage would be cut down two-thirds, with locks grouped together, when ships are ready to ascend and descend at the same time. This is met at Panama by making *all* locks doubled, so that the capacity of the canal is increased to passing a ship up and down through each lock at the same time, and the estimate of canal cost includes these double locks. The reason why the six double locks do not estimate very much more than eight single locks at Nicaragua is because:

* On the "mean-level dividing-lock system" now proposed these details are altered; the Panama canal is to have eight locks, grouped so as to require five entrance movements. The locks are still doubled.—THE EDITORS.

1st. Doubling adds only 50 per cent., roughly, to the masonry.

2nd. There are six structures against eight.

3rd. Clay foundations at Nicaragua require iron and concrete floors, and, finally, the total lift is 10 per cent. greater at Nicaragua.

As any accident to any lock would block the canal, it seems to me that, if any traffic is to be done, it is a necessary and obvious precaution to have each lock doubled—and that for a fair comparison the Nicaragua estimate should be increased to provide for double locks throughout.

LENGTH OF ROUTE AND TIME OF TRANSIT.

The Panama route is 46 miles from ocean to ocean, against 174 miles for Nicaragua. Of this transit, 29 miles at Panama and 49 at Nicaragua are in excavated channel requiring slow speed and careful navigation. In addition, careful navigation will be required through 83 miles of San Juan slackwater and dredged lake channel at Nicaragua, and through 17 miles of the summit lake at Panama. The latter is much freer navigation than the former, but it must not be forgotten that the distance must be made through a buoyed channel more or less sinuous. The detention from lockage will be much less at Panama, both because the locks are fewer, and because there is less loss of time by reason of taking three lifts in sequence.

TIME AT NICARAGUA.

49 miles, at	5 miles per hour	9.80 hours
83 miles, at	7 miles per hour	11.85 hours
42 miles, at	15 miles per hour	2.80 hours
8 lockages at	45 minutes	6.00 hours
Total		30.45 hours

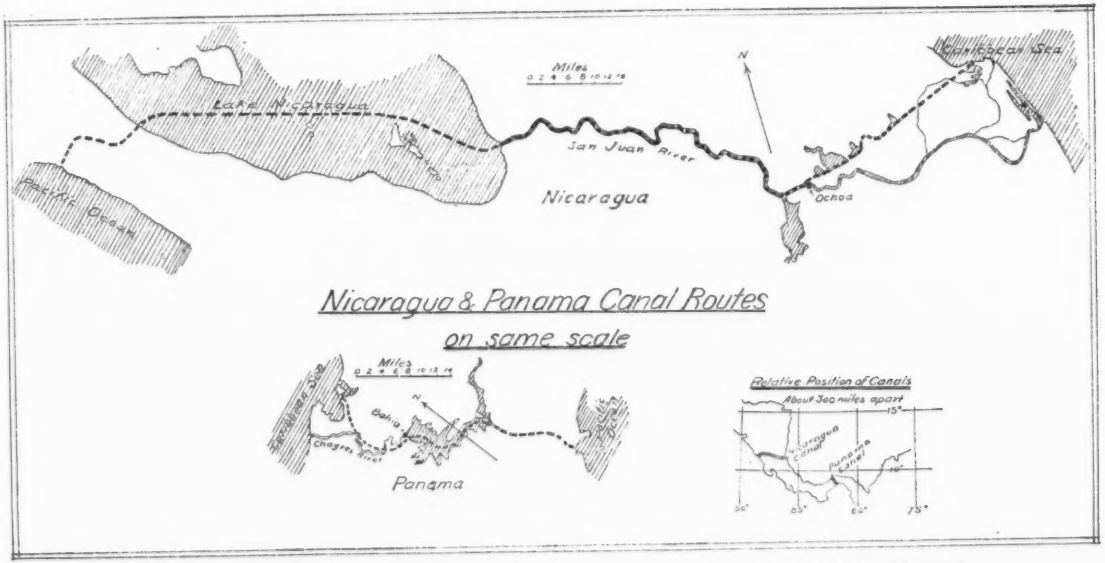
TIME AT PANAMA.

29 miles, at	5 miles per hour	5.80 hours
17 miles, at	7 miles per hour	2.43 hours
6 lockages at	35 minutes	3.50 hours
Total		11.73 hours

or a difference for steamers of nearly 19 hours in favor of Panama. The difference of towing time for sailers would be 28 hours.

COMPARATIVE COST.

The several classes of work are given for Nicaragua canal as found in the Ludlow report. At Panama there are only three classes of material—solid rock (mainly in lock foundations), dredgeable material



MAP OF THE PANAMA AND NICARAGUA CANALS ON THE SAME SCALE, SHOWING COMPARATIVE LENGTH.

in sea-level sections, and clays in the summit cut. These clays are not uniform in character, but all are of a type moveable by steam shovel without blasting. The lock estimate at Panama is the Wyse estimate, with prices somewhat higher per unit than used at Nicaragua. The railroad cost at Panama is for a change of line of the Panama Railroad, necessary to replace that portion to be submerged by the summit lake. No harbor-protection works are figured at Panama, because, with what has been done at Colon and the natural conditions in Panama Bay, none are needed. No rock protection for embankments is needed at Panama because there are no embankments; for revetting canal slopes, the figure used by the Ludlow commission for Nicaragua is also used for Panama. For engineering, hospital service, and buoys and lights, one-half of the Nicaragua estimate is used at Panama as a fair comparative allowance—there is only about one-half the work and the line is only about one-fourth as long. The Panama canal has been worked over from end to end, and there is in consequence no estimate for clearing and grubbing.

QUANTITIES AND COST OF EXCAVATION, BOTH CANALS.

Nicaragua.			Panama.	
Yards. e.	Value.	Per yard.	Yards. e.	Value.
12,300,000	$2,460,000	$ .20	5,950,000	$ 1,190,000
33,228,500	8,307,125	.25	20,300,000	5,075,000
10,596,191	3,178,857	.30	.....	.....
13,277,508	5,311,003	.40	.....	.....
7,166,060	3,224,727	.45	.....	.....
1,574,729	787,365	.50	.....	.....
12,742,962	7,445,777	.60	29,650,000	17,790,000
875,229	612,660	.70	.....	.....
13,618	13,618	1.00	.....	.....
7,593,735	9,492,169	1.25	.....	.....
1,092,978	1,639,467	1.50	.....	.....
8,340,393	14,595,688	1.75	3,524,000	6,167,000
2,389,723	11,948,615	5.00	.....	.....
111,191,626	$69,217,071	Totals.	59,424,000	$30,222,000

ESTIMATE FOR DAMS.

Ochoa.			Bohio.	
Cableways	$ 150,000	...	Cableways	$ 150,000
Sheet Piling.....	100,000	...	Sheet Piling	100,000
Abutments	550,000	...		
600,000 c. y. Earth.....	300,000	$.50	1,000,000 c. y. Earth..	500,000
2,000,000 c. y. Rock.....	1,400,000	.70	2,500,000 c. y. Rock..	1,750,000
River Sluices, etc.....	1,500,000	...		
	$4,000,000	Totals.		$2,500,000

GENERAL COMPARATIVE ESTIMATE FOR COST.

	Nicaragua.	Panama.
Clearing and Grubbing	$ 350,150	.....
Railroads and Telegraph	4,410,000	$ 2,400,000
Excavation	69,217,071	30,222,000
Terminal Dams	4,000,000	2,500,000
Locks	13,887,414	15,400,000
Sluices and Control Works	7,483,392	4,500,000
Rip-rap on Embankments	1,346,557	.....
Rip-rap on Canal Slopes	498,116	498,116
Harbor Piers, Breakwaters, etc	4,534,710	.....
Engineering	4,000,000	2,000,000
Hospital Expense	1,000,000	500,000
Lights and Buoys	500,000	250,000
	$111,227,410	$58,270.116
Add 20 per cent for Contingencies	22,248,482	11,654.023
Comparative Cost	$133,472,892	$69.924.139

The sea-level portions of the two canals will suffer to about the same extent from sloughing and wave action, to be easily repaired by dredging. Where the canal is in cuts rising above the water level, each hollow may be expected to contribute its stream, bringing down deposits and forming bars. There may be expected also land-slips, and an adequate equipment must be maintained to keep the channel clear. What maintenance expenses may amount to under the tremendous rainfall no one can form any idea. In a sea-level canal, such as Suez, in sand and with small current and 1½ inches annual rainfall, the operating expense for 1890 was about $1,500,000. Our two canals ought to be run for about equal management expense—but Panama would be cheaper in pilots, lights, and presumably in dredging and cleaning operations—certainly in proportion of canal excavation, or as about 29 to 49, and this difference may be a very large sum.

At Panama the transit is quicker, maintenance and operation probably much cheaper, construction difficulties less, and, finally, its cost will be only about one-half that of the Nicaragua canal.

Panama has harbors, wharves, machine shops, an interoceanic railroad, and organized transportation by land and sea. All these have to be created at Nicaragua to commence work properly.

The Panama line is cleared from end to end, worked over, with rails, locomotives, cars, hospitals and houses on the ground, much of it in good condition and ready to work with. At Nicaragua, a virgin forest and an abundance of swamps.

GAS ENGINES AND ELECTRIC STATIONS.

By Alton D. Adams.

ELECTRICAL-SUPPLY stations, deriving their entire income from the sale of the energy of coal, have a vital interest in the relation between the heat of combustion and the current at dynamo terminals. Steam-driven stations deliver, at best, but a small part of the heat from coal as electric energy, this being evident from a glance at the combined efficiency of the apparatus between the boiler, furnace, and distribution lines. Boilers of the best class, operated under favorable conditions, transfer into steam not more than 80 per cent. of the heat from the combustion of the coal. Compound condensing engines, at full and constant loads, transfer about 15 per cent. of the heat of steam into mechanical work at their shafts. Large dynamos, at nearly maximum loads, deliver, as electric currents, as much as 92 per cent. of the mechanical energy supplied to them. Combining these results, the dynamo current is shown to be but $80 \times .15 \times .92 = 11$ per cent. of the energy liberated by the combustion of coal. This result, corresponding to a consumption of about 1.8 pounds of the best anthracite coal per electrical horse-power hour delivered at dynamo terminals, is very close to the best that is possible with electrical supply from steam power, and the great majority of stations are probably using twice the amount of coal named per unit of output. The large increase in the amount of coal used at electric stations, over that necessary with the best economy, is due chiefly to lack of full and uniform loads and to the rapid changes in the conditions of load during the day.

It has been well known for several years that gas engines transform into mechanical work a larger part of the heat energy entering their cylinders than do steam engines. The 15 per cent. efficiency above named for the steam engine is quite close to the best that can be attained with large units of the best class, while gas engines, in very moderate sizes, readily show an efficiency of 20 per cent., and in units of several hundred horse power, under favorable conditions, as high as 25 per cent. in delivered power. Until a recent date the gas engine, in spite of its comparatively high efficiency, has not been considered available for general use in large power plants, because of the heavy investment and wide space required for gas-generating

plants, and more especially because the methods of gas production in common use yield such moderate portions of the heating power of the coal consumed.

The efficiency of 80 per cent. for steam boilers and 15 per cent. for steam engines shows a combined efficiency of $80 \times .15 = 12$ per cent. for the two, or a consumption per brake horse-power hour of $(2545 \div (.12 \times 13000)) = 1.63$ pounds of anthracite coal yielding 13,000 heat units per pound, one horse-power hour being the equivalent of 2,545 heat units. Coal-gas contains 25 per cent. and water-gas 60 per cent. of the heat energy of coal used in production, coke and other valuable materials being a residual product of the coal-gas process, but that for water gas leaving nothing of utility. The combined efficiency of coal-gas apparatus and the gas engine is thus but $25 \times .25 = 6.25$ per cent. for power production alone, and the efficiency of water-gas plant and engine is $60 \times .25 = 15$ per cent. It seems evident, therefore, considering the cost of coal- and water-gas plants, that their erection purely for purposes of power production is of questionable advantage.

Development of a third variety of gas apparatus, which costs only a moderate sum per unit of capacity and produces gas with a materially larger part of the energy of the coal than the above, now puts the gas engine in direct competition with the steam engine for large power plants. Producer gas is now readily made to contain 80 per cent. of the heat energy of the coal consumed, and the cost of such producer apparatus exceeds by only a moderate per cent. that of first-class steam-boiler plant of equal horse-power capacity. With producers that deliver gas having 80 per cent. of the heat energy of the coal, and gas engines transforming 25 per cent. of the heat from gas combustion into mechanical work, the efficiency of the combination is $80 \times .25 = 20$ per cent. With 13,000 heat units per pound of coal, this efficiency corresponds to a consumption of $(2545 \div .20) \div 13000 = .98$ pound per horse-power hour, instead of 1.63 pounds, as in the best steam-power plants. An electric plant driven by gas engines, operated by producer gas, is thus able to deliver at dynamo terminals $80 \times .25 \times .92 = 18.4$ per cent. of the energy of the consumed coal, against 11 per cent. in the steam-driven plant. The saving in the weight of fuel by the adoption of the producer-gas equipment amounts to $(1.63 - .98) \div 1.63 = 39.4$ per cent. of the coal required in the steam-driven station. This reduction in the total weight of coal for a given power development is not the only advantage as to fuel that lies with the gas plants. Producer gas is readily generated from grades of

coal too fine for use in the ordinary boiler furnace, and consequently of a very low market price.

Certain features peculiar to the operation of electric stations render the gas-producer plant especially suited to their wants. The average load of electric stations usually ranges between one-fourth and one-half of the maximum load. A change from average to maximum load, or from maximum to average load, at an electric station, commonly occurs within one hour. Maximum load seldom continues more than two hours out of the twenty-four. To meet these conditions the steam-driven electric plant must usually have engines and boilers of much greater capacity than that necessary for the average load. Great variety of loads makes it practically impossible to keep all operating engines at work to their full capacity, as is necessary to insure high economy. For wide and rapid load changes, boilers must be under fire during a large amount of time when their service is not required; this condition reduces the total boiler efficiency. These characteristics of electric stations have made the use of storage batteries general. The storage battery absorbs energy during times of moderate load, delivers energy at periods of maximum and also of minimum loads, and serves to steady the station pressure for momentary fluctuations of the demand.

Storage batteries thus tend to reduce, but do not do away with, the disadvantages to which the steam operation of electric stations is subject. In the first place it is not usually thought to be desirable, nor is it the practice, to install batteries of such capacity as to make the steam-engine load constant, so that the percentage of idle engines and boilers during a large part of the day is only reduced, not eliminated. The time occupied in getting up steam and drawing fires, in comparison with the entire time that some boilers are in use, is still too great for the best economy. Battery capacity is more expensive than engine capacity; all of the energy delivered by batteries must of course be first supplied to them by engines and dynamos, and the battery must waste some energy, as it cannot possibly return all that is sent into it. In spite of these disadvantages, these storage batteries have proved to be the best adjuncts thus far discovered for steam-driven electric stations.

Where gas producers and engines are substituted for steam engines and boilers, in electric plants, the conditions of load peculiar to electrical supply can be more economically met. Considering first the steam boiler and the gas producer, their comparative adaptation for varying and widely different loads should be noted. Steam from a

boiler under regular work is used as fast as generated, the supply in the boiler at any instant being usually less than is required per minute. Even the water in a boiler contains comparatively little heat, as will be at once evident if the furnace fire is drawn and the engines kept at full load, while an eye is had to the pressure gauge. The same fact is readily shown by calculation, since, taking the temperature of boiler feed water at 212° F., and the boiler pressure at 150 pounds by the gauge, the heat units per pound of water at the maximum temperature corresponding to this pressure are 157.5 above the heat in the feed water, while the heat units above the feed per pound of steam are 1012.6, or more than six times as many, the latent heat of steam at 150 pounds gauge pressure being $1012.6 - 157.5 = 855.1$ heat units. The water in a boiler, therefore, contains less than one-sixth of the heat necessary to convert the water into steam. The regular tubular boiler, with a full supply of water, contains the amount necessary for work at rated capacity during from four to five hours, but the heat in this water above 212° F. is only about equal to that given off by the boiler in steam during $4.5 \div 6 = .75$ hour. In water-tube boilers the energy in the contained water usually bears a smaller ratio to the boiler capacity per hour than that just shown. It is thus quite evident that the steam boiler can only act as a reservoir of stored energy to a small extent, so far as the varying loads of electric stations are concerned. Some effort has been made to store energy at electric stations during times of light loads by hot water in heat-insulated tanks, but this system has not met with much favor. Any plan to store energy in hot water or steam labors under the great disadvantage that the capacity for work in these substances is present in the active form of heat, which constantly tends to escape, while the energy of the storage battery, like that in coal, is only set free by chemical action, and is thus readily retained until such action is permitted.

Producer gas, like the other varieties, has a capacity to do work, not because of the free energy in it, but only on combustion. Gas may, therefore, be stored for an indefinite period with no material loss of energy, and used either slowly or rapidly, as desired. It follows at once that the capacity of gas producers for an electric plant need correspond only to its average daily requirement, and is much below the rate of gas consumption at times of maximum load. Gas producers for an electric-supply station may thus be operated regularly at the most advantageous rate, and not forced in and out of service to meet the varying exigencies of public demands, as are steam boilers. As a station load rises rapidly, near the period of its maximum, it is only

necessary to start the proper gas engines and their dynamos, without changing in the least the conditions of work at producers.

With a gas receiver of moderate capacity for an electric station, no question like that of constant steam pressure at boilers during times of hardest work has to be considered, as the supply of gas to the engines goes on at the same pressure whatever the number at work or their stage of load. The drop from maximum load, which in electric stations is as rapid as the rise, does not involve with gas producers the disadvantages incident to steam boilers quickly put out of service. As only the gas engine and dynamo capacity must correspond with the maximum machinery output of an electric station with gas producers, the burden of investment, for the brief periods of maximum load, is not so heavy as with steam plants, where boiler equipment must increase with the engines. In an electric station equipped with gas plant, the gas receiver fills, in large measure, the purpose of a storage battery, so far as concerns the accumulation of surplus work at one time and its delivery at another. A result is that in stations with the gas equipment the desirable battery capacity, in relation to total output, is much reduced. Smoke prevention in most steam-driven electric plants remains in practice an unsolved problem, for which gas producers offer a sure and practicable remedy. Briefly, gas producers and engines have the following advantages over steam equipment for electric stations: Considering the best obtainable results, for each class of apparatus, the steam plant consumes $(1.63 - .98) \div .98 = .66$ per cent. more fuel than the gas equipment. The conditions of operation at electric stations do not permit the most economical performance of steam plant, but have a much smaller influence on the efficiency of gas equipment. Not only the amount of coal, but also its necessary quality and price, are reduced by the adoption of gas producers and engines. The gas receiver renders storage batteries unnecessary, except for pressure regulation, and thus greatly reduces the cost of battery plant and the energy lost in its double transformations.

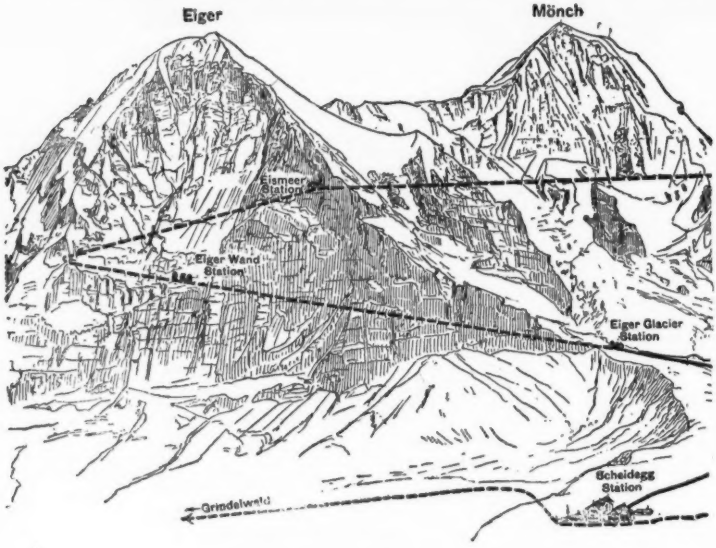
THE JUNGFRAU THREE-PHASE ELECTRIC RAILWAY.

By Ernest Kilburn Scott.

WHEN the Swiss Federal Council was asked to grant a concession for building a railway to the summit of the Jungfrau, most people received the announcement with a considerable amount of scepticism. Long study on the spot by engineers accustomed to mountain railways showed, however, that, with the help of electric power all the difficulties could be surmounted at a reasonable cost. The late Mr. Guyer-Zeller, of Zürich, commenced studying the question in 1890, and, having satisfied himself that the line could be built from Scheidegg with a maximum gradient of 25 per cent., and that it was possible to bore in solid rock across the neck of the Jungfrau, he obtained the concession in December, 1894. A sum of 30,000 francs was placed at his disposal by the railway commission for the purpose of awarding a premium for the best scheme, stipulation being made that the maximum gauge should be 1 metre, length of tunnel 10 kilimetres, minimum radius of curvature 100 metres, and the speed 7 to 10 kilometres per hour. It was further decided to work the line electrically, by water, from one of the neighbouring rivers.

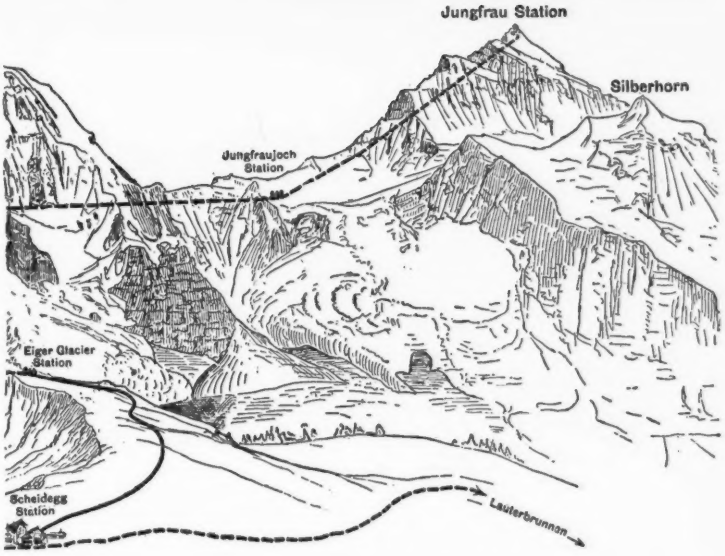
In August, 1896, after having considered the various memorials and selected six of the most favourable, the commission settled the line of railway and rail laying was commenced.

The problem then presented itself whether continuous or three-phase motors should be used on the locomotives. It was evident, having regard to the great distance which separated the generating station from the transformer stations, that it would be necessary to transmit the electric power primarily by alternating currents at high tension and transform down by static transformers and rotary converters to continuous current, or by static transformers only, using three-phase motors on the locomotive. Messrs. Wüst-Kunz (an electrical engineer of Seebach) and Thormann (of the Oerlikon staff), were asked to study the problem and draw up comparative estimates. They found that in the first case, where the three-phase currents are transformed into continuous currents, the cost of the installation came out at £38,000, whereas, by the exclusive employment of three-phase currents, the cost would be only £25,000. It was therefore decided to adopt this latter method.



PANORAMA OF THE JUNGFRAU RANGE.

The cut below furnishes a key to the upper engraving. The extension of the range and the road appear on page 35, facing.



CONTINUATION OF THE VIEW OPPOSITE. THE JUNGFRAU PEAK.

The lower view, from a slightly different point, shows less foreshortening of the stretch between the Mönch and the Jungfrau.

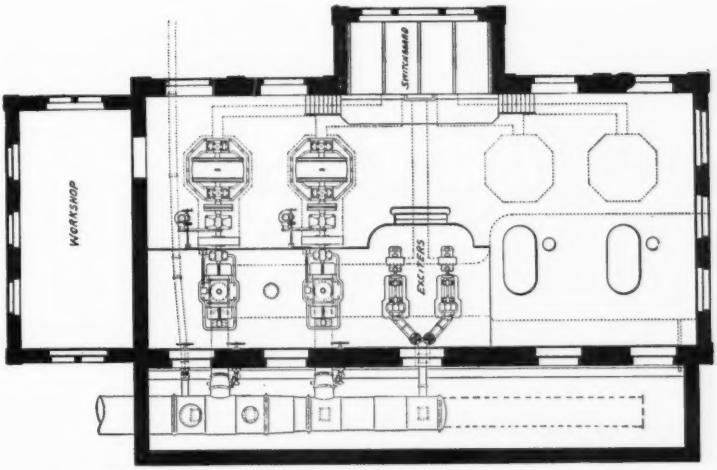
In September, 1898, the first section was opened, whilst the tunnel, which was commenced about a year earlier, has now been pushed forward to the Eiger station, which, as will be seen from the following table, is fourth on the list:

Sub-Station.	Name.	Distance between Stations.	Above Sea Level.	Total Distance from Scheidegg.
		Metres.	Metres.	Metres.
1	Scheidegg	2 000	2,064	.....
2	Eigergletscher	.....	2,321	2,020
3	Gorge	950	.....	2,950
4	Eiger	1,000	3,270	3,950
5	.....	950	.....	4,900
6	Eismeer	940	.....	5,840
7	.....	1,000	.....	6,840
8	.....	1,000	.....	7,840
9	Jungfrau Joch	1,000	3,393	8,840
10	.....	1,090	.....	9,930
11	.....	1,090	.....	11,020
12	Jungfrau Kulm	1,080	4,166	12,100

There are twelve transformer stations for the complete line, the last being reserved exclusively for controlling the lift. The presence of these numerous transformer sub-stations assures to the working of the line much greater security than a small number of larger stations, because, in the latter case, should one station fail to act on account of an accident, the train service would most probably be brought to a standstill. The two first sub-stations are in the open, and are constructed of solid masonry, to withstand the action of the weather. The remainder are in the tunnel and consist of transverse galleries abutting on a large opening, from which tourists can admire the panorama. The question of slips and avalanches has been carefully considered before fixing the position of these windows, so that there will be no danger to travellers.

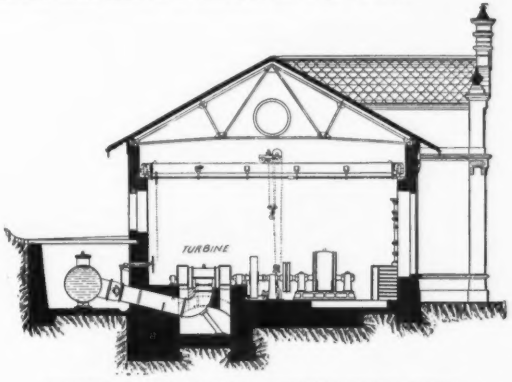
When the line is completed there will be two power stations—one of 2,300 horse power, on the White Lutschine, at Lauterbrunnen, which is already at work, and the other (the Burglanen station), on the Black Lutschine, near Grindelwald. This latter station, which has yet to be built, will have an output of 2,600 horse power.

The water for the generating station at Lauterbrunnen is tapped from the White Lutschine, immediately above the bridge of the Wengern Alp Railway, where a dam and basin for getting rid of gravel have been built. After passing the gates the water enters a steel pipe line, 1.8 metres internal diameter and constructed of rivetted sections. The first, or buried part, of the conduit is nearly horizontal, 690



PLAN OF POWER STATION ON THE WHITE LUTSCHINE, AT LAUTERBRUNNEN.

metres long and in sections of 6 metres each and 5 millimetres thick. The second and lower conduit is 625 metres long, in sections 7·35 metres each and 6 millimetres and 7 millimetres thick; being in the open, it is provided with expanding joints. A large-section vertical pipe forms the junction of the upper with the lower conduit and serves to avoid shocks and ensure a smooth flow of water.



SECTION THROUGH LAUTERBRUNNEN POWER HOUSE.

Between the dam and the turbines the difference in water level is 40.8 metres, but, allowing for friction, loss, etc., the really useful head may be reckoned at 35·5 metres.

The turbines, by Messrs. J. J. Rieter & Co., are six in number, of the twin Gerard type, with axial flow and automatic regulation.

	One Main Turbine.	Three Main Turbines.	Two Exciter Turbines.
Effective fall in metres.....	35.50	35.50	35.50
Volume of water in litres per second....	2250	1430	72
Horse power,.....	800	500	25
Number of revolutions per minute.....	380	380	700

The alternators, by the Oerlikon Co., are of the inductor type—that is, with the stationary armature and field coils. They generate at a pressure of 7,000 volts, the frequency of the current being 38 periods per second. The armature windings are divided into two equal parts, disposed on either side of the inductor bobbin. The movable part is composed of cast steel, carrying a series of laminated poles.

The alternators are insulated from the ground by porcelain insulators, Rafford flexible couplings serving to insulate the alternator shaft from the turbine.

Each of the two exciters is capable of producing 150 amperes at 120 volts when running at 600 revolutions per minute, the two machines together being sufficient for the four alternators. Experience

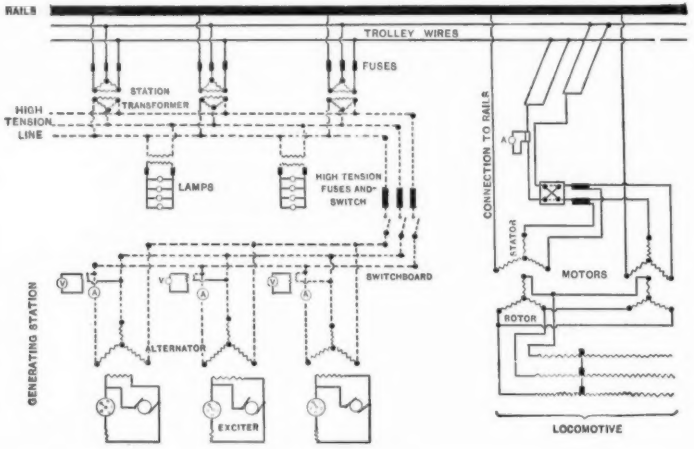
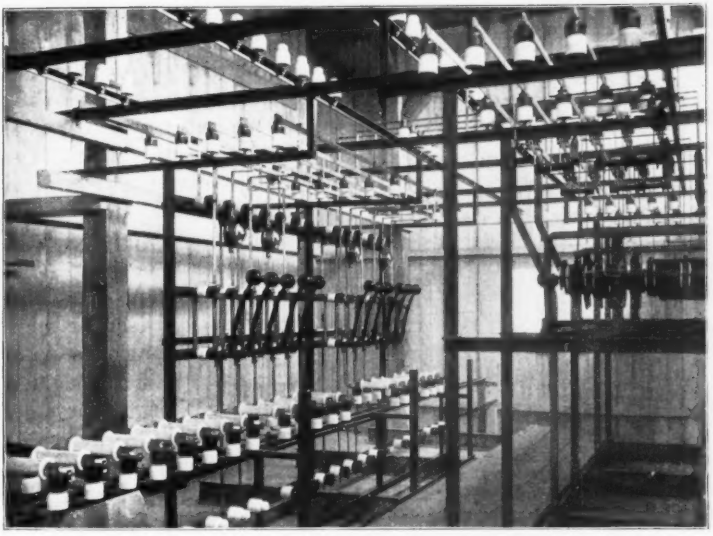


DIAGRAM OF SUB-STATION ARRANGEMENT, SHOWING SWITCHBOARD CONNECTIONS.



THE BACK OF THE SWITCHBOARD, LAUTERBRUNNEN STATION.

has shown that in hydraulic stations, where the load is very variable, it is better to have separately driven exciters. Rheostats are provided in the shunt circuit of each exciter, and also in each alternator.

The alternator circuits are star connected, whilst the sub-station transformers are in delta. The fittings on the switchboard are arranged as shown in the diagram of connections. A feature of the switchboard arrangement is that all the dangerous work is situated in a room at the back. The high-tension fuses consist of wires run in porcelain tubes, open at the ends and lined with fire-clay. The total expense of the generating station, including buildings, dam, pipe line, generating plant, etc., works out at about £11 per horse power of plant installed, which, considering the situation, is a low figure.

The road is formed from end to end of steel rails fixed on iron sleepers. The normal length of each rail is 10.5 metres, or exactly three times the length of the rack sections. The height of the rails is 100 millimetres, and the weight per metre run is 20.6 kilogrammes. The junction of the rails is effected by means of square fishplates, notched on each side to grip the chairs; the ends of the rails are cut to 45 degrees, in order to secure as smooth running as possible. Each joint has two Chicago bonds of 7 millimetres diameter, and the rails are cross-connected by copper wire 8 millimetres in diameter.

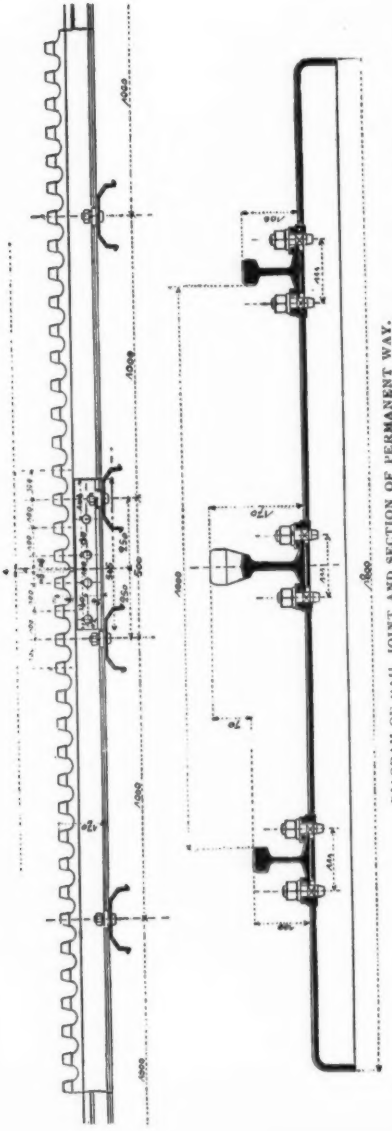
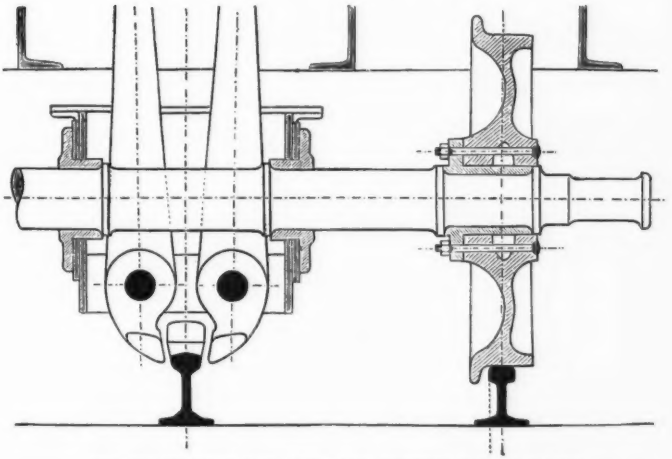


DIAGRAM OF RAIL JOINT AND SECTION OF PERMANENT WAY.

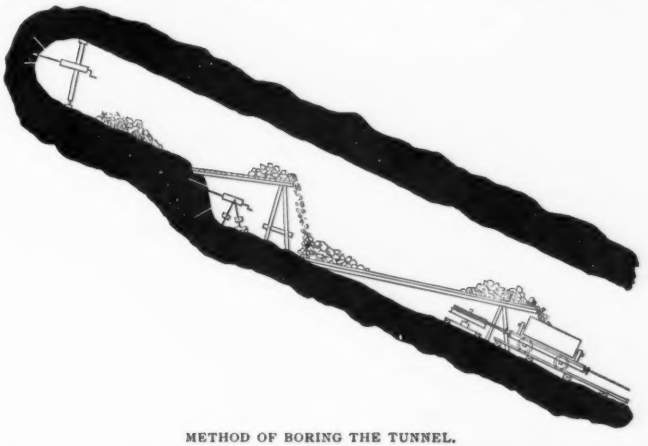
The rack is of "Strub" sections, with a broad head, permitting the employment of clamps to prevent rising of the locomotive. It was at first intended that these clamps should also serve as safety brakes, but this has been found impracticable. The material of the rack has a tensile strength of 45 kilogrammes per square millimetre, with an elongation of 20 per cent. The weight is only 34 kilogrammes per metre run; the complete track, with sleepers, fish plate, etc., weighing 130 kilogrammes per metre. The teeth of the rack are cut from the solid steel in the following manner: Two one-inch holes are first drilled at the bottom of the tooth space, and the metal is then sawed out, the saw working at the requisite angle. Afterwards the wedge-shaped bottom of the tooth space is milled out and the rail is cut off to the exact length and the holes for the fish plates drilled.

The tunnel is being pierced through a calcareous rock, which is remarkably tenacious and solid and little affected by the atmosphere. It is a most advantageous kind of rock for the boring of a tunnel, be-



SECTION THROUGH RAIL AND RACK, SHOWING SAFETY CLAMPS.

cause of the facility with which it bursts under the action of explosives, besides which it is sufficiently firm not to require any covering of masonry. Of the ten kilometres, at least eight will be through this excellent material. The total expense of boring the tunnel is expected to be £200,000. The cut below shows the method, boring being



METHOD OF BORING THE TUNNEL.

carried on at two places, a low gallery being first formed, having the full width of the tunnel. At the face two electric drills pierce a series

THE ENTRANCE TO THE TUNNEL.

of holes, one metre deep, and when the cartridges have been placed in position the workmen retire to the nearest cross gallery. As the blasting operation can only take place about four times a day, the daily progress is, of course, limited to four metres. The débris passes into tipping wagons worked by an endless rope, and is emptied out at the nearest cross tunnel.

At the entrance to the gallery there is a temporary building containing two three-phase 200-kilowatt transformers, reducing pressure from 7,000 to 500 volts. The three-phase, low-tension currents thus obtained are used for driving the electric drills, working a ventilator to clear out the smoke after an explosion, and providing power to melt snow for the drills. The lighting of the tunnel is provided for by 16-candle power lamps at 25-metre intervals, the stations having 100 lamps of 16-candle power. The heating will be carried out by 10 radiators, each of 1 kilowatt capacity. When the tunnel reaches a height of above 3,000 metres, it is expected that difficulties will be encountered on account of mountain sickness. At present the majority of the workmen employed are Italians, but above 3,000 metres it is almost certain that they will have to be replaced by Swiss mountain-

eers. It may be mentioned that the sickness only attacks those engaged in fatiguing work. Tourists are not likely to be troubled with it.

There are two types of drill in use, one the rotary type, supplied by the Oerlikon Company, the other the percussion type, constructed by the Union Electricitäts Gesellschaft, of Berlin.

The rotary drills are mounted on a vertical carriage, provided at the top with a screw to fix it between the floor and ceiling. The drill is actuated by means of a small three-phase motor of 3 horse power. Water is provided to clear out the cuttings and to keep the tool cool. The following gives the results of a test, under working conditions:

	Depth of hole, millimetres.	Time occupied in boring, minutes.	Amperes.	Volts.	Number of revolutions of motor per minute.	Number of revolutions of drill per minute.
1	700	8.5	6.0-7.5	220-230	1040	37
2	950	13.5	5 0-9.5	210-215	1060	36
3	550	10	5.5-8.5	215-227	960	33
4	350	6	6.5-7.5	217-220	960	33

ROTARY DRILL, OPERATED BY 3 HORSE-POWER THREE-PHASE MOTOR.

The percussion drill is worked by pulsating currents, and consists of two solenoids enclosed in an iron cylinder carrying the rotating mechanism of the drill. Within these solenoids there is a core of soft steel, one extremity working inside the rotating mechanism and the other extremity carrying the drill. As the current is sent alternately into the bobbins the core reciprocates backwards and forwards.

A three-phase motor drives the special generator, producing pulsating currents at 200 volts. This generator consists of a continuous-current four-pole dynamo, provided with an ordinary commutator

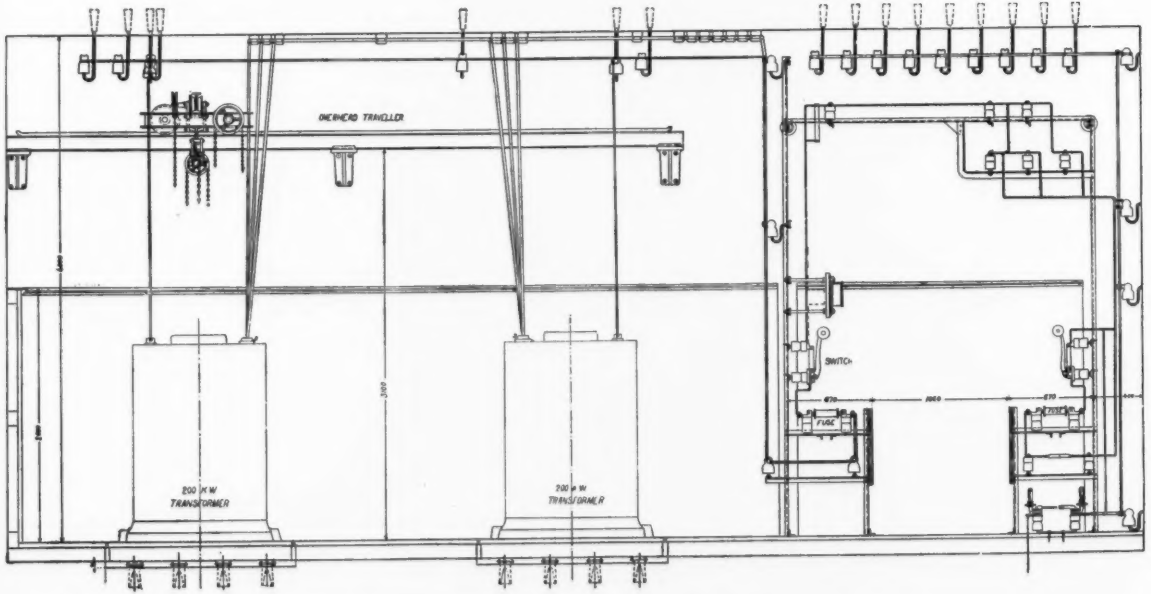
BORING MACHINES IN THE TUNNEL.

for its own excitation, and also collector for sending the current alternately into one or other of the solenoids. As the generator revolves at 400 revolutions per minute, it follows that 400 strokes of the drill are made in the same space of time.

The following is the result of a test made by one of these drills:

	Depth obtained in ten minutes.
Very hard granite	441 millimetres
Granite	458 "
Very compact slate	465 "
Ordinary slate	536 "
Slaty rock	752 "

Percussion drills give the best results and are most suitable for rocks of great hardness, which the auger drill will not touch. The



SECTIONAL PLAN OF SUB-STATION AT SCHEIDEGG.

solenoids have the disadvantage of heating excessively after a few hours' work.

The transformer station at Scheidegg is the first of the sub-stations so far erected. It contains two 200-kilowatt transformers, with provision for a third. The sub-station at the Eiger glacier is similar. The three-phase transformers reduce the pressure from 7,000 to 550 volts, and are made by the Oerlikon Co. They have three cores, disposed vertically and connected top and bottom by cross strips of soft metal. The primary and secondary bobbins are wound on separate formers, and are then slipped over the cores, so that, by simply removing the upper yoke, which forms part of the protecting cover, a coil can easily be replaced. The complete apparatus is protected by expanded metal, thus allowing the bobbins to be clearly seen when at work. The sub-station in the tunnel has, besides the 200-kilowatt transformers, a separate room, in which is a 42-kilowatt transformer which transforms current down to 120 volts, the three secondary conductors being connected to a three-phase motor, direct coupled to a continuous-current dynamo. This motor-generator set is for supplying current to charge accumulators, these latter being necessary for lighting and heating the stations and houses when the generating plant has ceased to work.

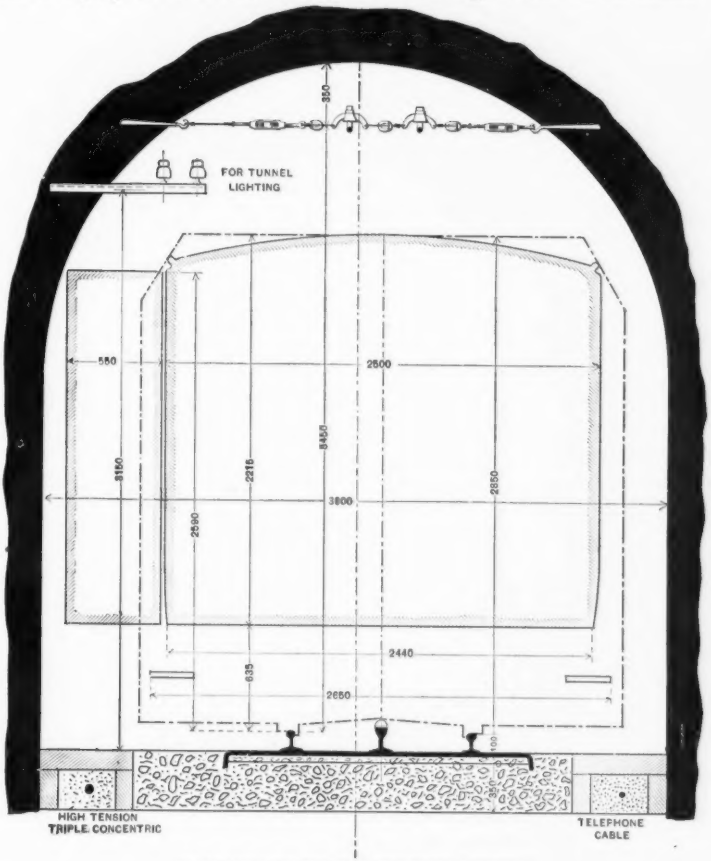
The primary line from Lauterbrunnen to Jungfraukulm will cover a distance of about 22 kilometres, and is calculated for a loss of 10 per cent. The line is composed of three wires, of 7.5 millimetres diameter, of hard-drawn copper, mounted on triple petticoat porcelain insulators 4½ inches diameter by 7 inches high, on fir poles 10 metres high, impregnated with sulphate of copper.

The Lauterbrunnen-Scheidegg section is 6,500 metres in length and the difference of level between the extreme points is 1,300 metres. By reason of the difficulty of access to the line in winter, it was absolutely necessary to give to the poles the greatest stability and therefore many of them have been erected in duplicate, the one leaning towards the other. Wherever the lines cross a pathway they are surrounded by a guard net to prevent the wire falling on the path in case of breakage. The telephone wires (the line has a complete metallic circuit) are fixed underneath the three-phase wires and are crossed at intervals of about 500 yards, to reduce induction noises.

Until the tunnel is reached all the cables are carried on poles, but in the tunnel the high-tension line is laid underground in the form of a triple concentric cable. The cable is imbedded in sand and enclosed in an earthenware trough. A many-stranded telephone cable con-

nects the sub-stations to Lauterbrunnen; this latter is also laid in sand and enclosed in an earthenware trough.

Since lightning is the cause of much trouble in this district, arresters of the Siemens and Halske horned type are placed at all points where injury could be sustained. It is interesting to note that statistics



DIAGRAMMATIC SECTION THROUGH TUNNEL.

of accidents which have happened on telegraph lines show that such lines are more exposed to attack in the plains and valleys surrounded by high mountains than on the summits of the mountains themselves. Overhead wires in the neighbourhood of lakes are especially liable to be struck by lightning.

The trolley wires are calculated for a drop of 12 per cent. and consist of two copper wires, each 9 millimetres in diameter, supported by means of transverse wires from wooden poles placed on each side of the road. These poles also serve to support the telephone wires.

HIGH-TENSION TRANSMISSION LINE BETWEEN LAUTERBRUNNEN AND SCHEIDEGG.

The trolley wires are placed 4 metres above the rails and are suspended at 18 to 25-metre intervals by span wires. When exactly between the two stations, as in the cut opposite, which means 1,000 metres from the nearest transformer, there is a drop of 12 per cent. in the voltage. In this position the locomotive is obtaining half of the current from Scheidegg and half from Eigergletscher station, and the voltmeter registers the lowest voltage obtainable. As the locomotive leaves the central position, the volts rise gradually, in proportion to the distance of the locomotive from the transformers, and by this means the driver can tell almost exactly the distance his locomotive is from the nearest station, without reference to land marks or signals. Since the speed of every locomotive is almost constant, and signals are given at the station when they start, the drivers also know each other's position. The line is single in the tunnel and double in the stations, where the locomotives pass each other. If one locomotive arrives at the station before the other, it must wait for its arrival. If, on passing

the centre point between two sub-stations, the loss increases above 12½ per cent., the driver at once knows that something is wrong, or that the other locomotive is on the same section. It will thus be seen that the system tends to great safety in working. Of course, the usual precautions of block signals, etc., are taken to avoid any possibility of an accident.

At one of its extremities the body of the coach is supported on the locomotive, whilst at the opposite end it is supported by a bogie. In this way the toothed wheel on the locomotive is kept in gear and the coach has no need of special brakes. The coach is pushed up the hill, and the coupling is sufficiently elastic to permit of easily passing the curves. The total weight to be moved is about 50 tons, with, say, 40 passengers. The coach is lighted with 15 lamps—5 between each pair of wires.

The frame of the locomotive rests on two axles by means of spiral springs, the play of which is limited to 10 millimetres in each direction. The first two locomotives put into use were built at the famous Winterthur works and equipped electrically by Messrs. Brown, Boveri & Co. Each of the two motors is capable of developing 150 horse power at 760 revolutions per minute, and it actuates a rack wheel through double reduction gear, disposed symmetrically on each side. The long cylinder immediately over the motors encloses the rotor resistance coils, there being one resistance for the two motors.

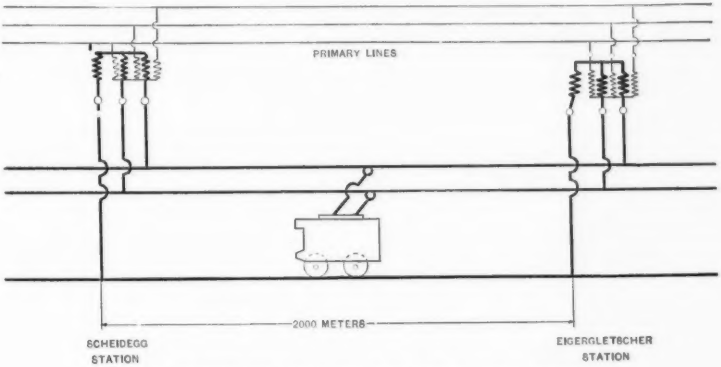
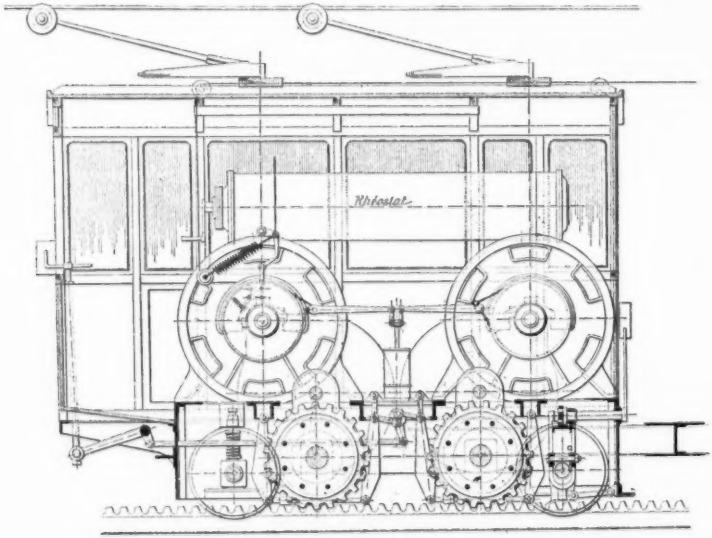


DIAGRAM OF PRIMARY LINES, TROLLEY WIRES, AND CONNECTIONS.

The superstructure of the locomotive is completely covered in by a wooden cabin, on account of the low temperatures which have to be encountered. Current is taken from the overhead wires by four trolley

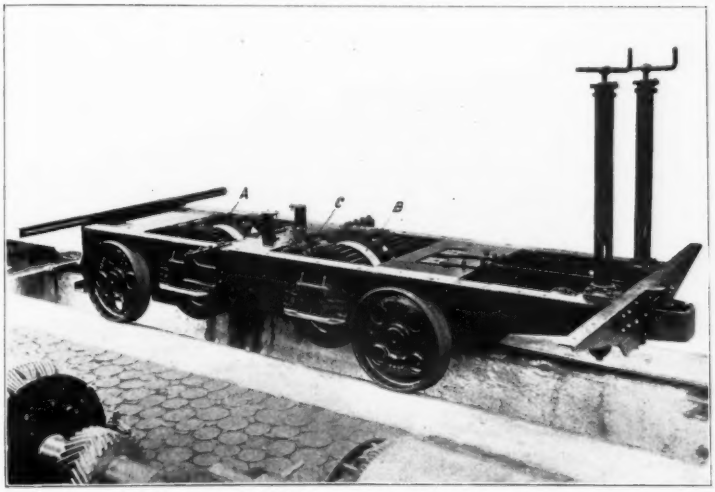
poles. The Oerlikon Company have recently supplied three more locomotives of greater power, representing the latest practice in three-phase locomotive design. Each of the motors gives 200 horse power when running at 550 revolutions per minute, the speed being reduced by two trains of gearing—1 to 4¼ and 1 to 2 respectively.

The truck (page 51) has four axles, the two inner ones being driving axles, carrying the rack pinions. These pinions (22 teeth) are of aluminum bronze, and forming an extension on either side are the grooved brake wheels, B. There are four of these brake wheels, each with four grooves, into which are set the brake blocks, C.



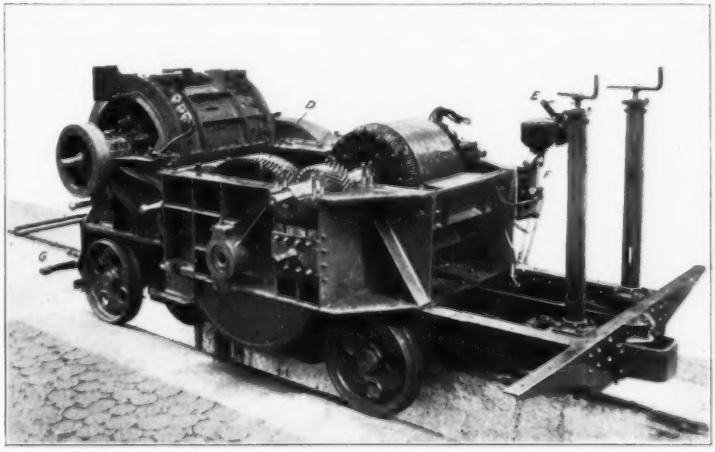
DIAGRAMMATIC SECTION OF LOCOMOTIVE, SHOWING AUTOMATIC BRAKE.

The double helical wheels, shown in the figure opposite, are the pinion and spur wheel, D, of the first reduction gear. The automatic brake gear, E, is worked by a chain from the motor shaft. Should the speed of the motor, by any chance, rise above a certain limit, a piece of metal on the rotating half of a friction coupling is moved out of position, causing the coupling to grip, and by this means rotating the screw, F, which is attached to the above-mentioned brake blocks. G is the projection for connecting to the passenger car, this latter resting on the locomotive at one end, so as to give greater adhesion and safety in working the trains.

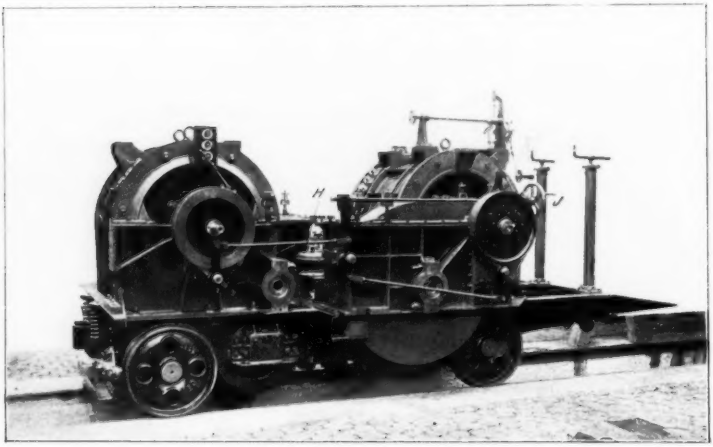


TRUCK OF ELECTRIC LOCOMOTIVE, JUNGFRAU RAILWAY.

There is a resistance for each motor, and H, (see next page), is a small three-quarter horse-power motor, which is coupled to a fan immediately below the coils. J is the wheel of the hand brake; the mechanism is plainly visible; the brake wheels are of cast iron, whilst the bands are lined internally with copper.



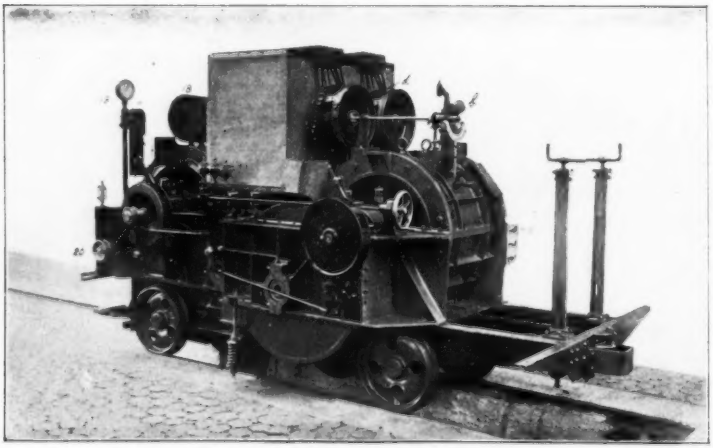
JUNGFRAU ELECTRIC LOCOMOTIVE, PARTLY BUILT.



A LATER STAGE IN THE ERECTION.

In the figure below, *d* indicates the rheostat switches, connected together by a steel band; 18 is a water reservoir, from which pipes are taken down to the grooved brakes, whilst 19 is a tachometer, on which the driver can read the speed of the motor shaft.

The completed locomotive is shown on page 54, and it will be noticed that two sliding contacts are used in place of trolley wheels.



READY FOR HOUSING IN.

The weight, complete, is 17 tons (or 5 tons heavier than the first locomotives); of this, each motor weighs 2 tons, and the cover 1½ tons.

Below is shown a diagram of connections of the Oerlikon locomotive, K being a three-pole switch, one pole of which is connected to

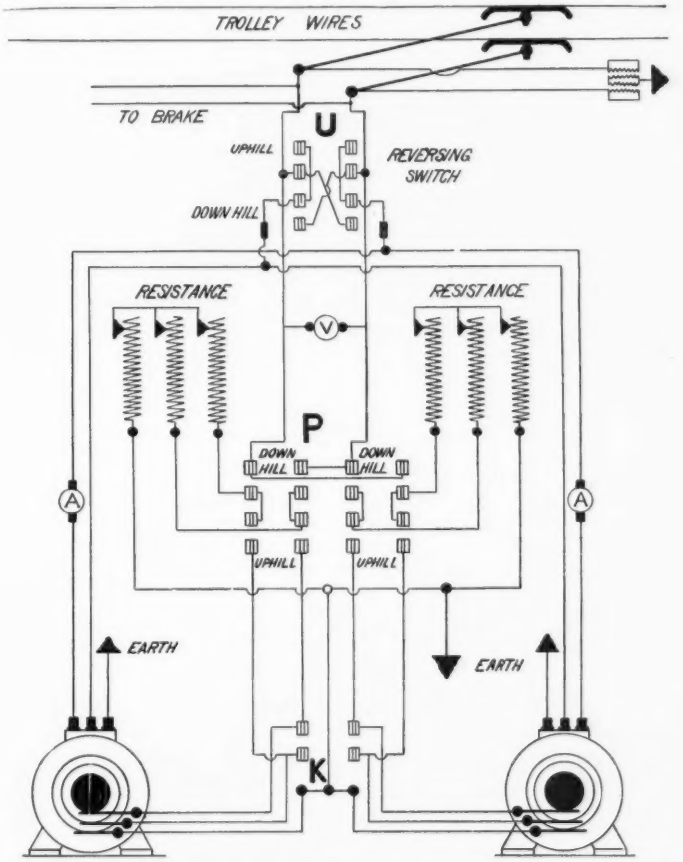


DIAGRAM OF CONNECTIONS OF THE OERLIKON LOCOMOTIVE.

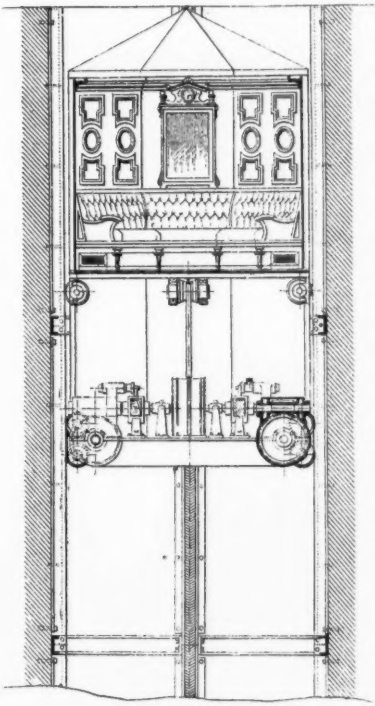
earth. U is the reversing switch, and P is a switch for altering the resistance connections. On starting the locomotive up hill, K is open and the full resistance is in each rotor circuit to give the necessary torque. U and P are switched over to the up-hill position, and, as the locomotive speeds up, the resistance is gradually cut out. On the steep-

est gradient the locomotive starts of itself directly the brake is taken off, but on low gradients current is necessary to start the locomotive, because of the rack friction. In this case, K is open and the full resistance is in each rotor circuit. U is reversed for running down hill, and P remains unchanged. When the locomotive has started, K is closed, the resistance is switched in and P connected for down-hill running. By following the connections it will be seen that the resistance is now in parallel with the stator circuit.

The reason for this arrangement is the small amount of traffic

JUNGFRAU RAILWAY ELECTRIC LOCOMOTIVE, COMPLETE.

at present on the line. Suppose, for example, that only one locomotive is going up and another coming down, and that the latter has reached its highest permissible speed and is supplying current to the one going up. Now if the ascending locomotive stops at a station, or for any other reason, the load on the descending locomotive is suddenly removed and may cause a dangerous increase of speed—so much so that the generating plant at the central station may be motored round. In the first locomotives which were built, this contingency was guarded against by having a resistance in the main circuit at Lauterbrunnen, so that when a locomotive was about to start



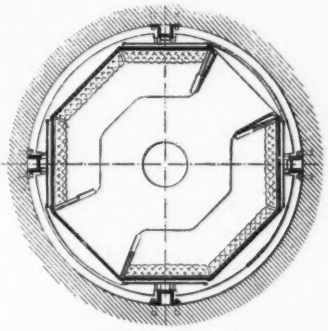
SECTION OF ELECTRIC LIFT.

it was necessary to signal to the central station to have the resistance temporarily switched in. When there is considerable traffic these inequalities of load on the generating plant will cancel out and the ideal method, in which those descending supply power to work those ascending, will be employed.

The last station of the railway will be about 66 metres below the summit, thus permitting the use of a rocky plateau about 30 metres wide and 4,100 metres high. From here travellers will be carried to the summit—4,166 metres—by means of a lift, which has been specially designed by the Oerlikon Company.

A three-phase motor is carried on the car itself and turns two toothed pinions working into two racks fixed along the walls of the pit. There are also two other racks, in which will be engaged toothed pinions working the automatic speed regulators. All the machinery is placed under the floor of the car, and great speed is obtained, together with absolute security.

The question of the utility of the railway has been frequently raised. At the present time the summit is reached several times a year, the time occupied being about 100 hours, and the expenses about 100 francs for each guide and 80 francs for each porter. When the railway is finished the traveller will be carried to the summit in



PLAN OF THE CAR.

about 2 hours, without any fatigue or mountain sickness, and at comparatively little expense. The view from the Jungfrau is probably unequalled in the world, commanding, as it does, a vast stretch of glaciers and the superb peaks—the Aletschhorn, Finsteraarhorn, Weisshorn, Dent Blanche, Monte Rosa, Mont Cervin, etc. Beyond the benefit that it will be to the tourist, however, there is the advantage of being able to establish a permanent meteorological observatory at so high an altitude* and the great impetus it gives to engineering development.

It would be premature to discuss in detail the financial results of the undertaking, but assuming that 17,000 persons are carried annually, the receipts would amount to £21,200, thus:

10,000 persons conveyed to Eiger and back at about 20s.	£10,000
7,000 persons conveyed to Jungfrau and back at 32s.	11,200
	£21,200

The working expenses will probably be about

10,000 car kilometres at 4 fr. 80 c.	1,920
Electrical service	480
Sinking fund, etc.	3,300
	£5,700

So that the excess of receipts over the expenses leaves £15,500, and on a capital expenditure of £300,000 this provides for a dividend of 5 per cent.

Aesthetic objections are met by the simple fact that the greater part of the line must of necessity be tunnelled through solid rock, and the openings or windows at the various stations, by which travellers view the surrounding scenery, cannot be considered a disfigurement.

One circumstance, particularly favourable to the working of the line by electricity derived from water power, is the fact that the variations in the output of the two Lutschines accord exactly with the movements of travellers—that is to say, during the summer months the output is at its maximum.†

* The Railway Commission has to provide a sum of 100,000 francs towards the establishment of this observatory and contribute 6,000 francs annually towards its maintenance.

† In preparing the above article, I am indebted to various manufacturers of the plant, particularly the Oerlikon Company. I have also made use of such information as has already been published, including an important paper by M. H. Martin in Le Génie Civil.

THE WORLD'S SUPPLY OF COPPER.

By Frederick H. Hatch.

HAVING reviewed, in my preceding article, the general aspects of copper production and consumption—a subject of prime importance in view of the constantly expanding demands of the electrical and ship-building industries—and presented in detail the conditions in the United States, Spain and Portugal, and Japan, there remain for study the production of Chile, Germany, Australasia, and the thirteen minor contributing districts. For convenience of comparison, the table of production in 1898 is here repeated:

TABLE GIVING THE PRODUCTION OF FINE COPPER FOR 1898 IN VARIOUS COUNTRIES.*

Country.	Tons of 2,240 lbs.
United States	237,173
Spain and Portugal	53,225
Japan	25,175
Chile	24,850
Germany	20,085
Australasia	18,000
Mexico	10,435
Canada	8,040
South Africa	7,060
Russia	6,000
Norway and Sweden	4,095
Italy	3,435
Peru	3,040
Bolivia	2,050
Newfoundland	2,100
Austria-Hungary	1,540
United Kingdom	640
Argentina	125
Algeria	50
Total	427,118

Chile.—This country has been an important producer since the middle of the century, the total output of its mines from 1844 to 1898 being estimated at 1,771,000 tons of copper, chiefly exported to Great Britain in the form of "Chile bars." Its production now, although important, is about half what it was twenty years ago.†

* Compiled from H. R. Merton's "Principal Copper Supplies" for 1899 and Rothwell's "Mineral Industry for 1898."

† About 1870, Chile furnished about half the world's supply of copper.

The figures of Chilian production for five years are:

Year.	Tons of 2,240 lbs. of Fine Copper.
1894	21,340
1895	22,075
1896	23,500
1897	21,900
1898	24,850

Two classes of veins are exploited, viz., veins of chalcopyrite associated with iron pyrites, with abundant copper carbonates and silicate near the surface, occurring in country rock of igneous origin, and more complex veins composed of sulphides of copper, lead, zinc, silver, and in some cases antimony. These ores are worked in innumerable mines, chiefly in the provinces of Atacama, Coquimbo, and Aconcagua. Among the more important mines may be mentioned: San Juan, Carrizal, Higuera, Tamaya, Panulcillo. The falling off in the output of recent years is attributable partly to the exhaustion of the oxidised surface ores, partly to internal political disturbances. The ores are mostly smelted locally; out of a total export in 1898 of 25,120 tons of metallic copper, 81 per cent. was in the form of bars, 7½ per cent. in mattes, and 11½ per cent. was ore.

Germany.—The bulk (90 per cent.) of the copper produced in Germany is furnished by the Mansfeld mines in the Southern Hartz. These mines exploit a thin bed of bituminous shale carrying copper (kupferschiefer) belonging to the Zechstein formation and extending over a superficial area of about 190 square miles. This seam is taken out to a width of about 15 ins., and for this width has an average copper content of 2 to 3 per cent. and a silver value of about 5 ozs. to the ton. It has been worked since the beginning of the thirteenth century, and by the fifteenth century the output had risen to about 1,000 tons of copper per annum. The metallic contents occur as a fine dust consisting of various copper sulphides (chalcopyrite, bornite, chalcocite), together with iron pyrites, galena, and small quantities of compounds of silver, cobalt, manganese, and other rarer metals. The mines are operated by the Mansfeldschen Kupferschieferbauenden Gesellschaft, of Eisleben. The ore is smelted in blast furnaces; the matte thus produced is roasted in kilns, and the gases are used for the manufacture of sulphuric acid. The roasted matte is smelted in reverberatory furnaces. The product consists of a second matte containing about 75 per cent. of copper and about 150 ozs. of silver to the ton, and copper bottoms containing 95 per cent. of copper and about 270 ozs. of silver to the ton. The second matte

is roasted for treatment by the Ziervogel process, and the copper bottoms are refined by electrolysis.*

After Mansfeld, the most important copper mines in Germany are those of the Northern Hartz, of which Rammelsberg, etc., is the chief. The Rammelsberg deposit is a big lenticular mass (some 3,500 ft. long by 50 ft. wide), intercalated in slates of Devonian age. Both in mode of occurrence and in mineral character it resembles the Huelva deposits. The ore is cupriferous pyrites, consisting mainly of iron pyrites with chalcopyrite, galena, tetrahedrite, blende, and heavy spar. A small amount of copper is also produced from chalcopyrite deposits associated with the diabase and schalstein (diabase tuffs) of the Nassau district. The returns of copper produced in Germany during five years are, according to Merton:

Year.	Mansfeld.	Other Sources.	Total.
1894	14,990	2,210	17,200
1895	14,860	1,695	16,555
1896	18,265	1,800	20,065
1897	17,960	2,185	20,145
1898	18,045	2,040	20,085

Australasia.—The production of copper in Australia was already large twenty-five years ago, the principal source of supply being the rich oxide and carbonate ores of South Australia. The highest point was reached in 1884, in which year the total Australian output amounted to 14,100 tons. In subsequent years the output fell off, owing in a measure to the partial exhaustion of the rich surface ores, but also to the influence of the low prices which succeeded the undue inflation of 1888. Low-water mark was reached in the year 1892, with an output of only 6,500 tons. Since 1895 the production has made rapid progress, being helped by the opening up a new copper field in Tasmania. The production of copper in Australasia, according to H. Merton & Co.'s estimates, has reached the following totals:

Year.	Tons.
1894	9,000
1895	10,000
1896	11,000
1897	17,000
1898	18,000

It is not possible to estimate the production for each of the seven colonies separately, as the official returns give the value of the output only, and this includes the value of the gold and silver contained in the blister copper exported. The following table shows their value

* "Min. Industry," 1898, p. 245.

for 1898 and the value of the total production up to the end of the same year for each of the seven colonies.*

Colony.	Value of Copper Production 1898.	Value of Total Production, to the end of 1898.
Tasmania	£382,640	£874,516
New South Wales†.....	280,887	4,624,029
South Australia	248,857	21,529,746
Western Australia	4,266	172,115
Queensland	2,166	2,022,927
New Zealand	70	17,938
Victoria	Nil	206,395
	£918,886	£29,447,666

Calculating from these figures we find that the three first named colonies are at present furnishing 99 per cent. of the value of the whole output; Tasmania contributing 42 per cent., New South Wales 30 per cent., and South Australia 27 per cent., leaving 1 per cent. for the remaining four colonies.

Tasmania.—Although this colony has only recently entered the lists as a copper producer, it has already caught up the two other big copper-producing colonies, viz., New South Wales and South Australia, the output of each of which may be roughly stated at 5,000 tons of metallic copper. This rapid advance is to be attributed to the development of the Mount Lyell mine, which up to the present time has been the sole producer of the colony. Other properties are, however, being developed in the Mount Lyell district. According to official figures,‡ the copper raised and exported during 1898 was 4,956 tons of blister copper and 394 tons of ore.

Mount Lyell is situated in the western part of the island, 14 miles from Strahan, which is the base of supplies and port of shipment. Several new mines are in course of development, but the producing mine is the property of the Mount Lyell Mining and Railway Company. The ore-body lies between schist (hanging wall) and conglomerate (foot wall). It is a lenticular mass of pyrites, having a length of 950 ft., and a width, at the widest point, of 300 ft. Its depth is unknown. The ore consists of iron pyrites, carrying about 14 per cent. of chalcopyrite, and associated with heavy spar (about 2 per cent.) and silica (1 per cent.).§ The average metal contents of

* Statistics of the seven colonies of Australasia, by T. A. Coghlan, Sydney, 1899.

† The Copper Mining Industry, Vol. VI., Min. Resources of New South Wales, by T. L. Carne, Sydney, 1899.

‡ Progress of the Mineral Industry of Tasmania for the quarter ending Dec. 31, 1898.

§ Report by Dr. Peters.

the ore are roughly; copper, 4 per cent.; silver, 4 ozs. to the ton, and gold 3 dwts. to the ton. The ore proper is overlaid by a gossan deposit consisting of hydrated oxide of iron and heavy spar, from which the copper has been leached out, but which carries good gold and silver values. The mine is worked on the "open-cast" system, and the ore is treated by pyritic smelting to matte, followed by Bessemerising of the matte and finally by electrolysis.

The amount of ore treated during the half year ending March 31, 1899, was 102,978 tons (dry weight), having an average grade of 3.25 per cent. of copper, a silver value of 3.85 ozs., and a gold value of 2.28 dwts. Since the commencement of operations up to the same date the company has mined 322,510 tons (dry weight) of ore, having an average assay value of copper, 3.96 per cent.; silver, 4.17 ozs., and gold, 3.18 dwts. to the ton; it has produced 11,209 tons of blister copper, containing 98.8 per cent. of copper, 106.43 ozs. of silver, and 4.612 ozs. of gold to the ton; this corresponds to an average copper yield of 3.4 per cent., calculated on the ton of dry ore.

New South Wales.—Copper mining commenced in this colony in the year 1845, and from that date to the end of 1898 the value of the blister copper produced, including the contained gold and silver, is estimated to have been £4,624,029. The most flourishing period of the industry was in 1883, when the value of the production reached £472,982. The subsequent fall in prices and the exhaustion of the richer surface ores brought many of the mines to a close.

The value of the net export of blister copper, regulus, and ore from New South Wales, according to official statistics,* is as follows:

1894	£63,617
1895	136,969
1896	197,804
1897	283,174
1898	280,887

The principal copper mines at present producing are situated in the central part of the colony, between the Macquaire, Bogom, and Darling rivers. Chief among them is the Great Cobar mine, which was opened in 1876 and closed in 1889, having produced during that period 23,610 tons of copper. It was reopened in 1895 by the Great Cobar Mining Syndicate, which is now operating, besides this mine, the Nymagee and other large mines in the district. The production of the Great Cobar mine, from the reopening to the end of 1898, has been 10,414 tons of copper. The output for 1898 was 3,520 tons.

* Carne, l. c., p. 189.

The ore-bodies consist of an admixture of chalcopyrite and pyrrhotite with iron ore and a small amount of quartz, occurring in lodes of varying width in ferruginous slates. Down to 300-400 ft. the ores consisted of carbonates and oxides of copper mixed with brown iron ore. In the local treatment the ores are first heap-roasted and then matte-smelted to 30-35 per cent. copper contents. The final yield is about 4 per cent. copper, ½ oz. of silver and 4 dwts. of gold to the ton. The gold yield, however, is enhanced by the use of gold quartz from neighbouring mines as a flux.

Other producers, but on a smaller scale, are the Burraga Copper Mining Co., the Girilambone Copper Mining Co., the Nymagee, the New Mount Hope, the Great Central, the Lake George United Mining Co., and the Broken Hill Proprietary Mines, the latter company producing copper in connection with its silver smelting operations. The production of these companies may be thus summarised.

Company	Nature of Ore	Copper Contents per cent.	First Opened in	Total Product, Tons	Output 1898, Tons
Great Cobar	Chalcopyrite and pyrrhotite	4	1876	34,024	3,520
Girilambone	Sulphides in quartz gangue	3.85	1880		421
Burraga	Chalcopyrite with quartz gangue	6.5	1880		570
Nymagee	Chalcopyrite and pyrrhotite	2	1880		728
New Mount Hope	Chalcopyrite below 160 ft.	4-5	1881	5,070	131
Great Central	Chalcopyrite below 200 ft.		1878	2,000	110
Lake George United	Chalcopyrite with pyrites, tetrahedrite, and zinc blende	1.45	1882		1,000

South Australia.*—The output for the entire colony of South Australia is a little less than 5,000 tons of copper, the bulk of which is derived from the amalgamated Wallaroo and Moonta mines. The Wallaroo mine is situated in Yorke Peninsula, Spencer Gulf. It was opened in 1860, and, prior to the amalgamation with the Moonta in

* There is much valuable information given in the "Record of the Mines of South Australia. Copper." By H. V. L. Brown, Gov. Geologist, Adelaide, 1899.

1890, had yielded copper ore to the value of £2,229,096. The ore-bodies are large lenticular masses (sometimes 20 ft. in width), connected by thin strings, and occur in schistose rock. The secondary ores (atacamite, cuprite, melaconite, chalcocite, etc.) extend down to 150 to 200 ft., giving place at that depth to chalcopyrite. The ore, as raised from the mine, has a copper content of from 3 to 10 per cent.

The Moonta mine is ten miles from the Wallaroo, in Yorke Peninsula. It was opened in 1861 and amalgamated with the Wallaroo in 1890. The ore-body consists of a quartz vein (3 to 8 ft. in width) in porphyry country rock, the ore being chalcopyrite with some bornite. Down to 150 ft. secondary ores were mined—red and black oxides, black sulphides, and atacamite. The average yield of the ore mined is about 3 per cent.

The Burra-Burra mine, situated one hundred miles north of Adelaide, was famous in Australia for its rich carbonate and oxide ore, having yielded for many years an average return of 23 per cent. of copper. This mine was discovered in 1845 and opened two years later. By 1850 it had attained to a large yearly output. Blue and green carbonates and red oxide of copper were found down to a depth of 300 ft., after which black sulphide ores began to take their place; below 600 ft., the ore had changed to chalcopyrite. On the exhaustion of the rich oxidised ores, the mine closed down in 1877. During the 29½ years of its existence it had produced 51,622 tons of copper, and paid £800,000 in dividends. The Kapunda mine, fifty miles west of Adelaide, was discovered in 1842, and worked from 1844 to 1879, producing over 12,000 tons of copper. The ore consisted of carbonates, oxides, and native copper, giving place in depth to chalcopyrite.

Mexico.—Before the advent of the Boleo mine as a producer in 1887, the output of copper from Mexico was restricted to a few hundred tons per annum; and at the present time 90 per cent. of the production is derived from Boleo, as will be seen from the table:

PRODUCTION OF COPPER IN MEXICO DURING THE PAST FIVE YEARS.

	1894.	1895.	1896.	1897.	1898.
Boleo	10,374	10,450	9,940	10,170	9,435
Other Mexican mines..	1,400	1,170	1,210	1,200*	1,000*
Total.....	11,774	11,620	11,150	11,370	10,435

The Boleo deposits are situated on the eastern coast of Lower California, the base of supplies being the port of Guaymas, on the opposite side of the gulf, whence the Sonora railway connects with

* Estimated.

the United States trunk lines. The deposits are stratified, the beds consisting of alternations of flows of trachytic and andesitic lavas with conglomerates derived from the volcanic rocks. The copper-bearing beds immediately overlie the conglomerates. There are three such beds, the lowest having a thickness of 2 to 10 ft., the middle of 2 to 3 ft., and the highest of about 3 ft. The copper occurs in various forms of the secondary ores, viz., oxides (cuprite and melaconite), carbonate (malachite and azurite), chloride (atacamite), silicate (chrysocolla). These minerals occur as spots, oolitic grains, and nodules (boleos) and small veins in a clayey deposit impregnated with carbonate and sulphate of lime and chloride of sodium. The ores have an average value of 5 to 11 per cent. They are worked by the Compania de Cobre del Boleo. The black copper resulting from smelting is shipped to the United States.

Canada.—Copper production in the Dominion of Canada is at present almost entirely confined to four districts, viz., Rossland (Trail Creek) and Nelson in British Columbia, Sudbury in Ontario, and Capeltown in Quebec. The following table summarises the output of copper (in tons of 2,240 lbs.) from these districts for five years:

	1894	1895	1896	1897	1898
Rossland	—	375	705	812	2,336
Nelson	—	50	1,000	1,542	1,873
Other districts in British Columbia	—	—	—	23	38
Total for British Columbia	145	425	1,705	2,377	4,247
Sudbury, Ontario	2,454	2,112	1,670	2,456	2,738
Other sources, chiefly Capeltown, Quebec*	856	1,386	815	1,081	1,029
Grand total for the Dominion of Canada	3,455	3,923	4,190	5,914	8,014

Rossland.—The gold copper mines of Rossland are situated in Trail Creek (a tributary of the Columbia River) in West Kootenay, a few miles north of the United States boundary line. The town of Rossland, which has sprung up within a few years to supply the wants of the mining camp, has railway connection both with the Northern Pacific and the Canadian Pacific Railways, but the ores are mainly shipped to American smelters in Washington. The ore-bodies are irregular masses occurring in basic eruptive rocks (gabbros and diabase), with which they are no doubt connected in origin.

* By difference.

and consist of a massive aggregate of pyrrhotite and chalcopyrite. They are low grade as regards copper (average yield about 1.3 per cent.), but contain high gold and silver values. The chief producers are the Le Roi and the War Eagle. The main ore chute of the Le Roi is more than 400 ft. long and its width is from 6 to 30 ft. During 1898 this mine sent 42,779 tons to its smelter at Northport, Washington (sixteen miles from Rossland), and these shipments which yielded 825 tons of copper, 68,000 ozs. of silver and 52,850 ozs. of gold, corresponding to a yield of copper, 1.9 per cent., silver, 1.6 ozs., and gold, 1.2 ozs. to the ton.

Nelson is situated on the Kootenay Lake, in West Kootenay. The mines in this district exploit silver-copper ores, consisting of a mixture of chalcopyrite, bornite, and tetrahedrite in a varied gangue. The average copper contents is about 4 per cent., but the main value lies in the silver contents. The chief producers are the Hall mines.

The nickel-copper mines of the Sudbury district are situated in Ontario, the town of Sudbury, on the Canadian Pacific Railway, being the base of supplies. The chief mines of the district (Copper Cliff, Stobie, etc.) are operated by the Canadian Copper Company, who, after heap-roasting and matte-smelting, ship the copper-nickel matte to the Orford Copper Company at Constables Hook, New York, for refining. The ore-bodies are irregular masses occurring in basic igneous rocks, and consisting of an aggregate of pyrrhotite and chalcopyrite, with smaller quantities of various nickel minerals. The average percentage of copper in the ore smelted is 2.8, and of nickel 2.6.

Capeltown, Quebec.—The pyritic deposits at the Eastern Townships (Capeltown) consist of chalcopyrite and iron pyrites occurring in Pre-Cambrian rocks. They are worked chiefly for their sulphur contents, the bulk of the raw ores being shipped to the United States for the manufacture of sulphuric acid. A small amount is treated locally by the Nichols Chemical Co., the sulphuric acid produced being used in the preparation of superphosphate from Canadian apatite. The copper contents of the ores are from 3 to 4 per cent., sulphur averages 42 per cent., and there is a silver value of about 3 to 4 ozs. per ton. The two producers are the Albert mine and the Eustis mine, the former worked by the Nichols Chemical Company, and the latter by the Eustis Mining Company. The output for 1898 was 35,686 tons of ore, worth $143,884.

South Africa.—The copper production of South Africa is at present confined to the mines in Little Namaqualand, in the north part of

the Cape Colony. The base of supplies is Port Nolloth, on the Atlantic coast, three hundred miles from Cape Town, which is connected with the workings by a light railroad (2 ft. 6 in. gauge) ninety-one miles in length. The mines are operated by two English companies—the Cape Copper Company and the Namaqua Copper Company. The principal mines belonging to the former company are Ookiep, Spectakel, Nababeep, and Koperberg; the work of the latter company is now chiefly confined to Tweefontein, the Concordia mine having been exhausted.

The ore bodies are irregular, massive deposits of copper and iron sulphides associated with basic igneous intrusions in the fundamental granite and gneiss of the country. At Nababeep the sulphides are intimately mixed with the component mineral of the greenstone, only in the richer places appearing in streaks, runs, and bunches in the body of the rock. At Ookiep the matrix of the ore is for the most part granite and gneiss, while at Spectakel the ores occur both in the granitic and in the basic intrusive rock. The bulk of the ore is chalcopyrite, but this mineral is associated with chalcocite, bornite, and iron-pyrites (marcasite). Cuprite and melaconite also occur, but in small quantities, while near the surface the carbonates (malachite and azurite) and silicate (crysocolla) are found. Some quartz and calcite occur in the gangue. Hitherto the Ookiep mine has been the principal producer. During the year ending April 30, 1898, 49,858 tons were raised from this mine, averaging about 10½ per cent. of copper. The sorted ore sent to the smelter averages about 17 per cent., and the resulting matte contained 51.8 per cent., of which 7,084 tons were shipped to Swansea.*

The Namaqualand Copper Company do not matte-smelt, but confine their surface operations to producing a high-grade concentrate (27 to 30 per cent. copper) by wet dressing.

The production of fine copper by the two companies for five years has been as follows (in tons of 2,240 lbs.):

	1894.	1895.	1896.	1897.	1898.
	1894.	1895.	1896.	1897.	1898.
Cape copper	5,000	5,350	5,470	5,290	4,660
Namaqualand copper	1,500	1,730	1,980	2,150	2,400
Total	6,500	7,080	7,450	7,440	7,060

Russia.—The principal supplies are derived from the Ural and the Caucasus, but other sources are the Altai and Finland.

	1894.	1895.	1896.	1897.	1898.
Output of Fine Copper in Tons of 2,240 lbs.	5,000	5,280	5,100	6,025	6,000

* Communicated by Mr. J. A. Chalmers.

The copper deposits of the Ural occur mainly on the eastern flank of the Ural mountains, in the districts of Bogoslowsk and Nijni-Taguil. In the Bogoslowsk district they occur chiefly as contact veins between intrusive igneous rocks and limestones. The ores consist, in depth, of chalcopyrite in association with iron pyrites or magnetite and a quartzose or calcareous gangue. Near the surface the ores are decomposed to the usual secondary production—oxides, carbonates, chalcocite, bornite, crysocolla, etc. The ores from the various mines are treated at Bogoslowsk by the Manhès process.

In the district of Nijni-Taguil, a rich mass or pocket of secondary ores is worked at Mednoroudiansk. The large blocks of malachite extracted from this mine have made it famous. The ores consist of the carbonates, oxides, phosphate, and silicate of copper, with an occasional association of native copper.

In the Caucasus the principal producer is the Kiadebek mine, which has been worked by the Siemens Company since 1864. It is situated in the Government of Elizabethpol, thirty miles from Dalliar Station, on the Trans-Caucasian Railway. The ore-bodies consist of large, irregular masses and bunches in quartz trachyte, which has broken through the surrounding diorite.* The ore consists of chalcopyrite associated with iron-pyrites, blende, and pyrrhotite. Chalcocite and native copper are rare. In the gangue, heavy spar and quartz are found. The copper in the ore varies from 3 to 5 per cent. At the surface it is separated into furnace ores, averaging 7 per cent., and poor material for the lixiviation plant, averaging 3 per cent. The smelting plant consists of reverberatory furnaces, using raw petroleum which is pumped up from Dalliar Station. The matte thus produced contains from 23 to 30 per cent. copper. After roasting, it is smelted to blister copper in blast furnaces. The blister copper contains 88 to 90 per cent. of copper, 2 lbs. of silver, and 1.2 ozs. of gold to the ton of copper. It is refined by electrolysis at Kalakent. The production of fine copper is about 1,800 tons per annum.

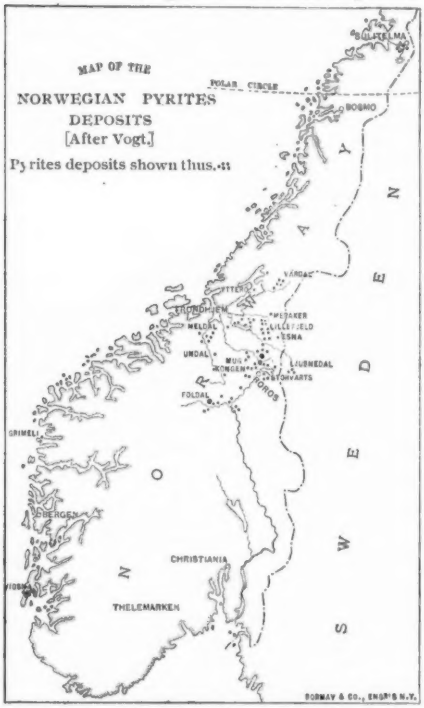
In the Altai the copper mines best known are those of Tschoudak and Songatof. The Tschoudak lode is of considerable width (up to 24 feet). The gangue is quartz, and the ore, below the zone of oxidation, chalcopyrite. In Finland the copper deposits of Pitkäranta have been worked for many years. The ore consists of chalcopyrite in a vein of sahlite, traversing granite.

Norway and Sweden.—The output from these countries during the past five years has been as follows:

* G. Kolle, "Min. Industry," 1898, p. 246.

	1894.	1895.	1896.	1897.	1898
Norway	1,890	2,685	2,500	3,450	3,615
Sweden	350	515	500	545	480
Total	2,240	3,200	3,000	3,995	4,095

A large proportion of the production is due to the operation of the Röros and Sulitelma smelting works. The remainder is chiefly derived from foreign treatment of exported ores.



The Sulitelma mines are situated in the province of Nordland in latitude 67° 15′. The port of shipment is Fineidet, twenty-four miles from the mines. The ore is chalcopyrite in association with iron-pyrites. After dressing, there are three products—smelting ore, having a grade of 7 to 8 per cent. of copper; lump pyrites, carrying on the average 5 per cent. copper and 45 to 46 per cent. of sulphur; and fines, carrying 3½ to 4 per cent. of copper and 45 per cent. sulphur.*

The Röros mines are situated south of Trondhjem on the railway from that place to Christiania. The ore-bodies are massive, often lenticular, deposits of pyrites occurring in metamorphic schists. In mode of occurrence and composition they bear a strong resemblance to the Huelva deposits. The ores consist of iron pyrites (greatly predominating), chalcopyrite, pyrrhotite, and blende, and are exploited for both their copper and their sulphur contents. Mining has been carried on in these deposits since 1646; the principal mines being the Storvarts, Ny Solskins, Mug, Christians, and Kongens. Similar deposits are worked at Vigsnäs, Foldal, Yttero, and other places in Norway.*

* Longridge, London Mining Journal, Sept. 10, 1898.

† Vogt: l. c. p. 243, and Zeitsch. f. Prakt. Geol., 1894, p. 41.

The Swedish production is principally derived from the Falun deposits, which are worked in the neighbourhood of the village of Falun, northeast of Stockholm. The deposits are lenticular segregations of quartz in gneiss, carrying iron pyrites, pyrrhotite, and chalcopyrite. The bulk of the ore is of low grade, containing 1 to 2 per cent. of copper, and is used for the manufacture of sulphuric acid; the "hard ore," *i. e.*, quartzose rock containing chalcopyrite and carrying from 3 to 4 per cent. of copper, is smelted for copper after concentration. The principal mine of the district, the Storrgrufra, has been working for more than five centuries, and has produced more than a million tons of copper. The present rate of production is between 400 and 500 tons of copper per annum, besides which there is a small yield of gold and silver.

Italy produces nearly 3,500 tons of fine copper per annum, as shewn in the following table:

OUTPUT OF FINE COPPER IN TONS OF 2,240 lbs.

1894.	1895.	1896.	1897.	1898.
2,600	2,500*	3,400	3,480	3,435

Smelting is carried on at Leghorn, where the smelting works consist of four Manhès converters and four reverberatory furnaces for refining. They treat ores derived from three sources, viz.: Monte Catini in the province of Lucques, Mossetana, and Boccheggiano. The dressed ores delivered to the smelters have the following copper values: Monte Catini, 36.06 per cent.; Mossetana, 11.21 per cent.; and Boccheggiano, 11.61 per cent. Of these three sources Monte Catini furnishes the largest production. Its ore-body is a brecciated lode in red serpentised gabbro (porfido rosso) made up of fragments of basic igneous rocks and carrying chalcopyrite, often in considerable masses of unusual purity, chalcocine and, more rarely, native copper. The average value of the ores as mined is about 7 per cent. of copper.†

Peru, which before the war with Chile in 1879 furnished a considerable amount of copper, has since then until last year been a very small producer. The industry has, however, undergone a great revival, owing partly to the opening up of new deposits in the Cerro de Pasco district. The output for five years is as follows:

	1894.	1895.	1896.	1897.	1898.
Output of Fine Copper in Tons of 2,240 lbs.	440	450	740	1,000	3,040

Bolivia.—The only production of copper in this country is derived solely from the famous Corocoro deposit in the La Paz district south

* Estimated.

† "Mineral Industry," 1899, p. 215.

of the Lake of Titicaca. The deposit consists of a bed of clayey and gypseous sand, having a thickness of 2 to 30 ft. The copper occurs chiefly in the form of grains and nodules of native copper with which are associated oxides and sulphides of copper, *e. g.*, chalcocite and cuprite. The product shipped contains as much as 60 per cent. of metallic copper and is known as *"copper barilla"* (barilla de cobre). The output of copper from this source for the last five years has been as follows:

	1894.	1895.	1896.	1897.	1898.
Output of Bolivia in Tons of 2,240 lbs.	2,300	2,250	2,000	2,200	2,050

Newfoundland.—The bulk of the copper ores shipped from Newfoundland are mined by the Cape Copper Company, at Tilt Cove, and are sent for treatment to Swansea. The output from Tilt Cove for the last five years has remained constant at 1,800 tons of copper. In addition to this, in the year 1898, 300 tons of copper were produced from ores coming from Betts Cove.

The ore bodies worked are lenticular masses of cupreous iron-pyrites, occurring in archæan rocks. As in other deposits of this nature, the ore is a mixture of iron-pyrites and chalcopyrite. The ore shipped carries about 7 per cent. of copper.

Austria-Hungary.—The copper production of the Austrian Empire is derived chiefly from bye-products in the various smelting operations carried on in many parts of the country. The principal copper deposits, worked as such, are those of Kitzbühel in Tyrol, those of Schmöllnitz in Hungary, and those of Rézbánya and other districts in the Banat.

The Kitzbühel deposits consist of beds, or flat lodes, of chalcopyrite and iron pyrites in a gangue of siderite and quartz traversing Silurian slates. The principal mine is the Kupferplatte. At Schmöllnitz, the ore bodies are lenticular masses of cupriferous iron pyrites in slates resembling the Huelva deposits. The Banat deposits occur on the contact of diorites (banatites) with cretaceous limestone. Chalcopyrite occurs associated with iron pyrites, magnetite, and blende. A small amount of copper is also derived from Bosnia and Servia.

The output for five years is as follows:

	1894.	1895.	1896.	1897.	1898.
Austria	1,810	1,110	1,075	1,210	1,110
Hungary (including Bosnia and Servia)	310	200	210	445	430
Total	2,120	1,310	1,285	1,655	1,540

United Kingdom.—The copper production from ores mined in the United Kingdom, once so important, is now reduced to very small limits. At one time (1830) Great Britain furnished over one-half of the world's supply of the metal. In 1850 Messrs. Foster & Whitney put the output of Great Britain at 14,000 tons, the world's total being 46,000 tons,* while in 1863 the production of the metal from local sources was valued at over a million sterling.

The output is now chiefly confined to Cornwall, Devon and Wales. In Cornwall, copper and tin ores are mined in the districts of Camborne, Redruth, St. Austell and Carrodon. The ore bodies are veins traversing granite and slate (killas) and the vein-filling is chalcopyrite together with iron-pyrites, the tin stone, blende, galena, siderite, and quartz. The chief Cornish mines now producing copper are the Levant at St. Just, the Carn Brea and Tincroft at Carn Brea, and the Creegbrawse at Chacewater. The Welsh production is contributed by the Hurst's mines at Dolgelly in Merionethshire, and by old mines on Parys Mountain in Anglesea, where copper "precipitate" is obtained by the treatment of cupreous water pumped up from abandoned workings.

The output is as follows in tons of 2,240 lbs.:†

	1894.	1895.	1896.	1897.	1898.
Cornwall	242½	394	399	294	376
Devon	152	132	104	93	71
Other English sources	3	1¼	2½	—	—
Wales	3	1	9½	67	166¼
Ireland	—	—	—	18½	—
Angelsea "Precipitate"	46	51	41	45¾	27
	446½	579¼	556	518¼	640¼

It does not require a very prolonged study of the foregoing notes on the world's copper supplies to arrive at one rather striking conclusion, namely, that although there are a great number of copper mines scattered over the globe, a very large proportion of the whole production is derived from comparatively few mines. Thus we find that three mines alone produce 28 per cent. of the total output. They are the Anaconda, the Calumet and Hecla, and the Rio Tinto; and if we extend the list we find that half of the whole world's output is the production of eight mines. They are listed below in the order of the magnitude of their production for 1898:

* U. S. Executive Document 69, p. 152.
† Blue Book: Mines and Quarries, 1899.

Name.	Tons of 2,240 lbs.
Anaconda	47,830
Calumet and Hecla	41,101
Rio Tinto	33,705
Boston and Montana	27,700
United Verde	18,900
Mansfeld	18,045
Copper Queen	15,066
Tharsis	12,000
Total output of eight mines	214,347
World output	427,118

The dominating position taken by the United States among the contributors to the world's supply of copper has already been commented on. The immense activity of the Americans, added to their mechanical genius, has led to the initiation by them of a scale of operations hitherto unprecedented in the history of mining. But, if the increasing demand for copper continues, present sources of supply will soon be insufficient, unless production at the big mines can be still further stimulated. It is doubtful, however, whether the production of mines like the Anaconda and the Rio Tinto can be very largely increased. And there is another side to the question that must not be lost sight of—the more rapidly an ore-deposit is exploited, the sooner it will be exhausted. It is true that there are immense reserves of copper ore at Lake Superior, assuming that the beds can be profitably worked down to a vertical depth of 6,000 to 7,000 ft.; but it seems likely that even this source of supply will fail to cope with the inincreased demands of the early part of next century, and three or four decades will probably see it exhausted. We are bound to assume, therefore, that unless new and abundant sources for the metal are opened up in the early part of next century, or some substitute is found for it in the electrical industry, there is no prospect of copper being over-produced.

LIMITS TO THE USE OF FORCED DRAFT FOR MARINE BOILERS.

By Walter M. McFarland.

WE do not hear so much nowadays about boilers being damaged and trial trips lost on account of the use of forced draft, but about ten years ago this was a complaint not at all uncommon. A part of the reason for the change is, as will be seen later, the increased use of water-tube boilers; but, nevertheless, the known fact that forced draft can be used within limits on any boiler with decided advantage suggests an examination to determine, if possible, what those limits are.

In order to understand such a discussion, it is well to glance briefly at the history of forced draft, and the article of Mr. James Howden, read before the International Engineering Congress in Chicago, in 1893, from which the abstract in the next two paragraphs has been taken, gives this in excellent shape.

Like some of the other important matters in connection with marine engineering, the application of forced draft to marine boilers is due to an American—Mr. Edwin A. Stevens, of Bordentown, New Jersey. His earliest experiment was in 1827, when the boilers of the steamer "North America" were fitted with closed ash-pit draft. A little later Mr. Stevens also tried two other methods—that by closed fire room, and that which is now known as induced or suction draft. Still another form, which is still common where the vessels ply in fresh water, is that of a jet in the chimney. This, of course, is rarely used with boilers in connection with salt-water navigation. Forced draft has been used on American river steamboats in various places almost continuously since the earliest days; but, so far as naval vessels are concerned, there had been, until some twenty years ago, no attempt to secure the benefits of forced draft, except for its use on nineteen small gunboats during the American civil war by Engineer-in-Chief Isherwood, of the navy.

In 1875 Thornycroft & Company began the use of forced draft on the closed fire-room plan in their torpedo boats, and from this time on its benefits became so apparent that it was universally adopted where weight was an important item. In 1882 it was applied to larger vessels, for the first time since Isherwood's test, in the case of the Satellite and Conqueror, of the British navy. The results there were

so satisfactory as to lead to the immediate adoption of forced draft for naval vessels of all sizes throughout the world.

In naval vessels there has always been a tremendous pressure upon the designer of the machinery to reduce his weights to a minimum, and the successful use of forced draft was hailed with delight, because it was at first assumed that by its use the capacity of the boilers could safely be increased about 50 per cent.—which, of course, meant a reduction of one-third in the number and weight of boilers, assuming that all other conditions remained the same. We shall see in a moment that the other conditions do not remain the same, so that, while the percentage increase may in some cases be considerably more than fifty above natural-draft power, this is accompanied by a diminution in the economy of steam production.

Before discussing the methods generally used for securing forced draft for sea-going vessels, it may be of interest to say a few words about the use of the steam jet for stimulating combustion. In the high-pressure steamers of western American rivers the whole of the steam generated in the boilers is available for blast purposes, just as it is in a locomotive, and under such circumstances it is obviously the simplest and most economical method of forcing the draft; but in sea-going steamers with surface condensers, where fresh water is very precious, it is also obvious that the possibility of using a steam jet for forcing the blast has decided limits.

In the United States navy the steam-launch machinery is of the compound or triple-expansion type, with surface condensation; but the draft is obtained with the assistance of a steam jet. This was brought about in the early days of Admiral Melville's incumbency as Engineer-in-Chief by the fact that his attempt to get very light machinery through the medium of forced draft with a blower was objected to on the score of noise—the little blowers, running at nearly four thousand revolutions per minute, making a decided hum. It became evident that a steam jet would have to be used, but there were no data in existence of the economy of different forms of jets; in other words, the jet had always been used where it made little difference whether it was wasteful or not, and no attempt had been made to measure the steam used to secure a given rate of combustion.

A very interesting series of experiments was conducted at the New York navy yard in 1890, where the evaporation and rate of combustion were measured in one boiler, while the amount of steam required to supply the jet for the first boiler was supplied and measured in a second one. Numerous forms of nozzle were tried, but it

was finally found that a nozzle of the simplest possible form (consisting of two cones whose narrow bases were joined by a short cylindrical neck) was the best, and by making the little cylinder of the nozzle of various diameters it was finally found that a combustion of 26.9 pounds per square foot of grate per hour was obtained with an expenditure of only 12 per cent. of the steam evaporated. This result is worth knowing, because, except for its publication in the report of the Bureau of Steam Engineering, the results of these experiments have not appeared in print. A nozzle of the same general form, but with a still smaller cylindrical portion, used only 8.3 per cent. of the steam evaporated, but it gave a combustion of only 14.2 pounds per square foot. This lower percentage was due both to the fact that the draft was not forced so much, and to the greater economy of evaporation with the lower rate of combustion.

Of the various methods of forced draft already mentioned, two have had the greatest vogue; that where the fire room is closed and the air forced into it, and that where the fire room is open but the ash pit is closed, either in the simple form or as part of the casing over the boiler front, the air in either case being forced into the ash pit and into a casing around the furnace door and thence over the fire. A modification of this latter form, with considerable elaboration for the purpose of heating the air forced in, is the system of Mr. Howden, which has probably been used more extensively than any other in merchant vessels, and is used almost exclusively to-day in the express steamers of all the great mail lines.

The system in which the fire room is closed and the air forced in—then acting just as in the case of natural draft—is the one which has been used most in the naval service, for the reason that it requires the fewest fittings and, generally speaking, is the simplest. In all war vessels the boilers are below the protective deck in any event, so that it requires very little additional structural work in the way of bulkheads to provide for placing the fire room under pressure.

The system by induced draft or suction has been used to some extent, and quite successfully; but its use does not compare in extent with the other two already mentioned, and for the purpose of this article it need not be further considered.

As showing the tremendous increase in boiler power due to forced draft, we may mention that the boilers of the U. S. S. Trenton, built in 1876, gave 5 horse power per ton of boilers and water, while the Minneapolis and Oregon, built in 1891-2, as well as the Prince George, of the British navy, in 1896, gave more than 17 horse power per ton

of boiler. The value of forced draft, combined with the express type of water-tube boilers, is shown by the data for the torpedo boats and destroyers, which, in some cases, have given results of more than 80 horse power per ton of boiler and water.

As already stated, it was in naval vessels that the great benefits to be derived from forced draft showed themselves in a most marked way, from the fact that in their case maximum power is wanted usually for a short time only, so that questions of the economical production of steam had very little weight. The only case in recent times in which forced draft was used under the conditions where it was expected to prove of most value, demonstrated this point of its short duration. The fight at Santiago lasted from the time forced draft was turned on until the Colon had surrendered—in all, four hours.

Inasmuch as the economy of steam production was of so little weight, the question of limitation in using forced draft has attracted attention from the injurious effects of high rates of combustion in boilers on trial trips, where every effort was made to get the highest power from the boiler. In the United States navy there was practically no trouble at all on this score, for the reason that Admiral Melville, who along with his intense spirit of progress has always exercised a wise conservatism, had insisted on providing an adequate amount of heating surface. The case where the greatest trouble was found was in certain English vessels, where the amount of heating surface per horse power had been greatly reduced, and in some cases was little more than one and one-half square feet per horse power. In the American navy the allowance was always at least two square feet. The trouble came in the form of leaky tubes in the combustion-chamber tube sheet, and in a great many cases it was found impossible to carry out the forced-draft trial to the full length of four hours. A partial remedy for this difficulty was found by the use of what is known as the "Admiralty ferrule," which had a curved flange protecting the end of the tube from the direct impact of the flame. It may be said, in passing, that these accidents happened always in the case of boilers with closed fire rooms, as none of the closed ash-pit type were used in the British navy. Of course, carelessness in firing might cause leaky tubes with any system of forced draft, as was found in the case of one American vessel where inexperienced firemen allowed the backs of the grate bars to become uncovered and the cold air from the ash pit had direct access to the tube sheets, causing a few leaky tubes by the end of the trial. Generally speaking, the closed ash-pit system has hardly any tendency to cause leaky tubes, for the

reason that when the furnace door is opened to put in a fresh charge of coal a damper is shut in the duct leading to the ash pit, thus cutting off the forced draft and leaving the open furnace under exactly the same conditions that obtain with natural draft.

Some of the brightest minds in the engineering world were devoted to a solution of the problem of preventing leaky tubes, and experiments were made showing the direction in which immunity was likely to be secured—one of which was the importance of not making the tube sheets too thick; another, the absolutely vital importance of perfectly clean water, free from grease; and another, the necessity of having a thoroughly good fit of the tube in the tube sheet without excessive expanding.

It was also very evident that the question of damage to the boiler was much more dependent upon the proportion between the amount of coal burned and the heating surface than on the usual ratio of coal burned per square foot of grate. The modern furnaces are so well adapted to stand the stresses due to expansion that, so far as that part of the boiler is concerned, it makes very little difference what amount of coal is burned per square foot of grate; but experience seems to show that in cylindrical boilers, if the rate of combustion is such as to make the heating surface less than about two square feet per horse power, with good triple-expansion engines working with about 160 pounds' pressure, there is danger from leaky tubes. In this connection it is worth remarking that in boilers fitted with the Howden forced draft the rate of combustion per square foot of grate is high, so that the horse power per square foot of grate rises to as much as 22; but in all these cases the number of square feet of heating surface per horse power is close to two.

As was already remarked, the advent of water-tube boilers has removed this question of damage done to the tube ends by high rates of combustion from the region of practical consideration, owing to the fact that in well designed boilers of this type, where there is any adequate provision for expansion, there has been no case of damaged tubes, however rapid the combustion. At the engineering congress already referred to, Mr. C. D. Mosher gave a report of a test of one of his boilers, where the air pressure was 12 inches of water, giving an evaporation of 18.2 pounds of water per square foot of heating surface. In the trials of the Ward boiler prior to its adoption for the U. S. S. Monterey, the rate of combustion was 55 pounds per square foot of grate for a period of 24 hours without any damage whatever, and in a short test of the boiler of the U. S. S. Cushing, with an air

pressure of 4 inches of water, the rate of combustion was higher than 66 pounds per square foot of grate without any damage. Indeed, this was one of the reasons which led to the readiness with which the water-tube boiler was accepted, although, of course, the prime reason was the reduction in weight.

Although in naval vessels the question of economy in evaporation was of secondary importance, it was nevertheless very interesting to have some actual data of the extra cost of forced draft, and Admiral Melville was the first one in authority to take any steps to procure this information. On the trials of the Newark, Concord, and some other ships, he had the coal used under forced draft accurately weighed, with the result of finding that the coal per horse-power was about 2.6 pounds, whereas before these actual trials many writers had estimated that the consumption would not be more than 1.8 or 1.9 pounds, and they had even figured on as low a rate as 1.3 pounds for natural draft. As a matter of fact, the most economical result which has ever been obtained with triple-expansion engines under conditions where the measurements could be absolutely relied upon was the case of the steamship Iona, where the trial was made under the direction of the research committee of the Institution of Mechanical Engineers, Prof. A. B. W. Kennedy and Mr. Bryan Donkin being in charge of the watches, with a thoroughly competent staff of observers. In this case, with every appliance for economy in the engine, and a remarkably economical boiler, the coal consumption was 1.5 pounds per indicated horse-power hour.

It may be said, in passing, that in the naval vessels tested under Admiral Melville's direction the ratio of heating to grate surface was about thirty to one, which would give good economy with a combustion of not more than 15 pounds of coal per square foot of grate; but obviously this ratio of heating to grate was too low for economy when as much as 40 pounds of coal were burned per square foot of grate, as was the case in the vessels tested. In the Iona, the ratio of heating to grate surface was seventy-five to one. It is unfortunate that no extended series of experiments on the economy of evaporation at different rates of combustion has ever been made on numerous boilers of different types. Almost the only one of which we have thoroughly reliable data is the case of the U. S. S. Cushing, where a very thorough series of experiments was made by a board of naval engineers under Commodore Charles H. Loring, U. S. N., and the fact of this being the only case has made it necessary to use this table in almost every article in which the question of economy at

different rates of combustion was under discussion. This table, with certain derived figures for the purpose of this article, is given below:

FORCED DRAFT TRIALS OF BOILER OF U. S. S. CUSHING.

(Thornycroft boiler of Speedy type; weight with water, 11 tons; grate surface, 38 square feet; heating surface, 2,451 square feet.)

Coal per hour, per square foot of grate, lbs.	24 12	40.23	66.32
Evaporation f and a, 212° per lb. of coal, lbs.	9.72	8.84	6.51
Coal per hour per i. h. p., at 18 lbs water, lbs.	1.85	2.03	2.77
Coal per hour for 10,000 i. h. p., tons	8.25	9.09	12.35
Coal per day for 10,000 i. h. p., tons	198	218	296
Extra coal per day over 24-lb. rate	.....	20	98
Extra cost per day at $5 per ton	.....	$100	$490
Number of boilers	20	13	11
Saving in weight of boilers and water, tons	.....	77	99
Time for extra coal to equal saving in weight, days	.....	4	1
Time for extra coal to equal saving in cost of boilers, days	.....	560	146
Same in months of regular service	.....	36	9.6

It is evident, on an examination of the observed data of this trial, that the rate of evaporation falls off in a marked degree as the rate of combustion is increased, so that two subjects suggest themselves for investigation. One is: "How long a period would elapse before the saving in weight of boilers, due to the increased combustion, would be offset by the greater expenditure of coal?" and the other: "How long a period would elapse before the saving in the cost of additional boilers necessary to run at economical rates would be offset by the cost of the additional coal used, due to the reduced economy?"

As will be seen by the derived data, in the case of a ship of 10,000 horse power, fitted with boilers of the type used on the Cushing, the difference between working at a rate of 24 pounds per square foot and 40 pounds per square foot would make the extra coal used at the higher rate equal the saving in the weight of boilers in four days, while, at the much higher rate of 66 pounds per square foot of grate, the extra coal burned in a single day would equal the weight of the nine boilers and their contained water, which would be dispensed with when this higher rate of combustion is used. Assuming that coal is worth $5.00 per ton and that the cost of one of the boilers, with its fittings, is $8,000, it appears that it would require 560 days of operation to make the extra coal used at 40 pounds per square foot of grate equal the value saved in boilers, and 146 days in the case of working at 66 pounds per square foot of grate. If we assume that, as in mail steamers, the vessels are in port about half the time, this would mean that the periods in which the cost of the extra coal would equal

the saving in price of boilers would be 36 months for the 40-pound rate and 9.6 months for the 66-pound rate.

In the foregoing I have simply compared the cost of the coal with the cost of the boilers, and have made no allowance for the earning power of the additional space, which would be saved in the case of long runs by using more boilers with a lower rate of combustion, nor have I made any attempt to allow for the fact that the deterioration of the boilers would undoubtedly be greater at the high rates of combustion than at the lower ones. To include all these factors would obviously complicate the problem seriously, but with a series of experiments at various rates of combustion, giving more points than in the case of the Cushing, so as to enable a fair curve to be made with accuracy, there is no doubt that it would be possible to lay out a series of curves for the different factors, from a study of which it would be possible to find exactly the rate of combustion with a given quality and price of coal that would prove most economical.

In the case of the Cushing we have already noted that, with the rates of combustion actually used, the additional amount of coal burned would be equal to the saving in weight of boilers in four days when the rate of combustion is 40 pounds, as compared with 24. It is quite evident that at some intermediate point, in the neighborhood of 30 pounds, the economy of evaporation would be increased enough beyond that at the 40-pound rate of combustion to make the balance between boiler weight saved and extra coal burned come at about six days, or the period of a Trans-Atlantic voyage. In such a case there would be no question of the possibility of carrying extra freight, and under these conditions this would be the most economical rate of combustion.

It becomes very evident from this discussion that the maximum rate of combustion to be used with advantage is not an absolutely fixed quantity, but that it depends upon the nature of the service to which the boilers are subjected and upon the possibility of damage to the boiler. In the case of water-tube boilers of proper design there is no danger of injury by any rate of combustion which would be thought of on other grounds, so that for this type of boiler the question is reduced to the nature of the service of the vessel on which the boilers are installed. In naval vessels, where maximum power is never wanted for more than a few hours at a time, it will probably be found that the number of boilers should be fixed by the consideration of the number which will enable long distances to be made with the greatest economy at the highest speed practicable for such con-

ditions. In other words, in the case of a 23-knot vessel like the Minneapolis and Columbia, the highest economical cruising speed for long distances would probably be somewhere between 17 and 19 knots. If the number of boilers is chosen so as to give a high economy of evaporation under these conditions, there will be no difficulty in having ample power for the maximum speed.

In the case of merchant steamers, questions of economy such as we have just discussed at some length, based on the data from the Cushing, would be the guide in connection with the length of the voyage and the earning power of freight capacity. Each particular service would be a case by itself, which the competent designer could readily solve by taking some little trouble to secure reliable data.

In the discussion as to the use of forced draft, the necessity for it on more important grounds has led me to omit hitherto one of the real advantages which it possesses for service on war vessels, which have to take their coal wherever they can get it, and which frequently cruise under conditions where natural draft would involve the use of a large number of boilers under conditions that would be wasteful on the score of added radiation and similar losses. Where forced-draft appliances are fitted, the question of securing any desired speed becomes a very simple one. I have had personal experience with cases where the coal supplied was of poor quality, and where the best firing gave very unsatisfactory results so long as natural draft was depended upon. The boilers were fitted with closed ash-pit draft, and in a very little time after the blowers were started steam was raised to the desired point, and after that there was absolutely no trouble in maintaining it at an even pressure. In another instance, where a forced-draft trial at full power with all boilers was made, there was every evidence from the difficulty in maintaining steam pressure that the coal was of very inferior quality. After the trial was concluded the blowers were shut down with the intention of allowing the fires in two boilers to die out. Ordinarily this would have required more than an hour, and would have enabled the speed to be kept up much above the ordinary cruising rate while the fires in the boilers to be laid off were dying out. In this particular case, steam began to fall in less than ten minutes after the forced draft had been shut off, and it was found that the fires in the two laid-off boilers had gone completely out. With such coal, no pretense of maintaining designed power could have been made except for forced draft.

There are some drawbacks to the use of forced draft, of course, one being the additional machinery necessary to produce the blast

and the attention it requires, and also the greater attention and skill which are required both in firing and in tending water. Where the men are trained, however, by frequent use of forced draft they become thoroughly familiar with it, and, in my experience, really prefer it in moderation to working with natural draft.

The best illustration of the benefit of forced draft, where the machinery has been under the charge of competent men, is the case of the Oregon at Santiago. Milligan's men had frequently been exercised in the use of forced-draft appliances, so that when the vital moment came for which they had been waiting since the journey from the Pacific began in March, they were ready; and in less than half an hour after the signal was given for full speed the great warship was driving ahead under the impulse of all the power in her great machinery, and carrying her guns forward to insure the destruction of Cervera's fleet. The "man behind the gun" did his part well, but if it had not been for Milligan and his "men behind the shovel" the Oregon would not have been the supreme factor in the fight at Santiago that she actually was. Here were all the conditions for success: an admirable design of machinery; the highest workmanship on the part of the builders; and unremitting care on the part of the chief engineer, his assistants and the men under them. Not a drop of salt water had ever gone into the boilers, nor any grease; every boiler had good clean fires in it; and the splendid Cardiff coal which Milligan had husbanded in the fighting bunkers for this very day was ready to do its work. Every one of these factors was necessary to success; none had been neglected; and therefore the success was complete.

THE GEOMETRICAL GENERATION OF IRREGULAR SURFACES IN MACHINE CONSTRUCTION.

By Henry Roland.

ONE highly important development of the tool-maker's art—that by which simple movements are compounded so as to generate geometrically those regularly-irregular surfaces which form the working faces of correctly shaped gear teeth—should be considered before the rapid review of tool-making advance can be considered at all complete.

This paper, dealing with the latest forms of gear-cutting machines, is therefore a supplement to the preceding series on "The Revolution in Machine Shop Practice."

The terms "geometric production" and "geometrically produced" are here used in a special sense, for want of an authorized term opposed to "mechanical production" and "mechanically produced," where such mechanical operations involve hand-made transfers of scribed lines to template surfaces.

Almost the entire round of machine forms are composed of spheres, cylinders, cones (which are cylinders of constantly varying diameter), and plane surfaces. These are simple geometric forms, readily produced by the use of the lathe and planing machine, although there is no machine tool in common use which will produce a really accurate plane surface, and the best flat work now known is merely an approximation, more or less close, to a true plane, and is produced by hand scraping and tested by being rubbed with "surface plates," which are themselves approximate planes dependent for their goodness on the skill of the hand scraper who finishes them.

There is, however, one highly important class of irregularly curved surfaces to be found in those coacting cam-faces which form the actuating parts or driving members of the toothed gear wheels which make an indispensable integral part of almost every machine constructed. It is not possible here to give even the briefest mention

The series on The Revolution in Machine-Shop Practice began in the issue of this Magazine for October, 1899. The preceding topics have been:

The Evolution of the Tool Maker.
Development of the Automatic Screw Machine.
Application of the Turret to General Machine-Shop Work.
The Practical Limitations of Tool-Making.
Application of Automatic Mechanical Production to Heavy Work.
The Machine Works of the Immediate Future.

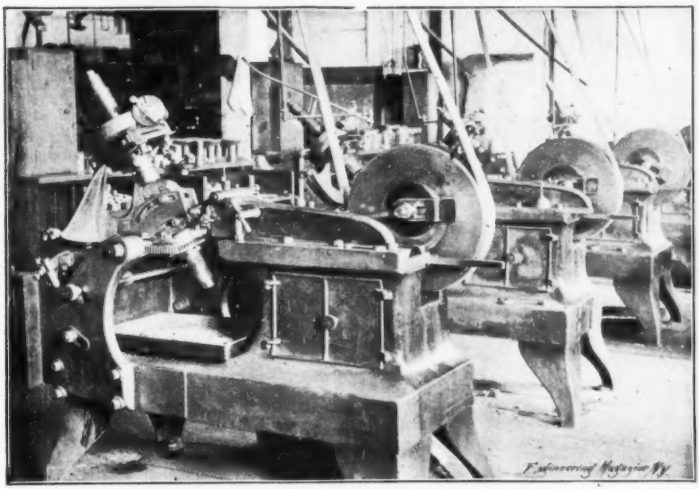
of all the make-shifts by which passable approximations to the correct forms of gear teeth have been produced. The practice of the world up to about 1865 may be said to have consisted wholly of hand work in the production of machine gears, which were up to that time either formed by casting from wooden patterns having hand-shaped teeth, or, in case of large "mortise" wheels, by hand-shaping wooden teeth keyed into mortises in a cast-metal wheel. About thirty-five years ago the superiority of machine-cut gear teeth became so well understood that there is now a disposition to machine the teeth of all gears, of even the very heaviest class, with revolving cutters formed as accurately as may be to thin metal templets, which templets are themselves hand-shaped in accordance with approximately correct lines hand-traced on the templet blanks. Hence it may be said that no gear teeth very closely approximating to their really best forms were ever produced before the discovery that combinations of movements about centers could be made which would enable a cutting tool, having one of the simple geometric forms, to cut the infinite variety of shapes of wheel teeth which real accuracy demands.

In all forms of gearing the true shape of the working face of the gear varies with the number of teeth in each individual wheel, and hence, to approach the correct form with a hand-shaped cutter, there should be a different cutter for every difference in tooth-number of each pitch used, which is not commercially practicable. Hence all gear-cutting mills, commonly called "cutters," are approximations, each one made to cover as large a tooth-number variation as may be, and giving the truly correct form to none.

As previously mentioned, the only metal forms which can be geometrically produced involve the circle, and the only non-circular metal surface which can be tested for accuracy is the plane. It is obvious, therefore, that any machine which is to generate geometrically varying irregular forms bearing definite relations to each other, must derive its movements from circular and plane surfaces, since the correctness of no other surfaces can be accurately tested by methods practicable in the machine shop.

Almost any conceivable form of projection from the surface of a disk can be made to serve all the working purposes of an individual gear tooth, since some form of projection may be made on another disk which will take an impulse at uniform velocity therefrom, and the early millwrights and the makers of gear-driven bicycles of to-day meet on a common plane as producers of strange forms of gear teeth. But the wide demand is not for any form of gear tooth capable

of special application only; what is wanted is a gear tooth of such shape that all diameters of driving-gear wheels shall impart a smooth motion at a continuous uniform speed to all diameters of driven-gear wheels having the same "pitch," or distance between the centres of adjacent teeth on the pitch circumference. This demand for interchangeability makes symmetry of tooth shape an indispensable requisite. Both sides of the tooth on any one wheel must be alike, and all teeth of any given pitch must be of the same total height, and have the same projection beyond the pitch circumference and the same descent below the pitch circumference into the body of the

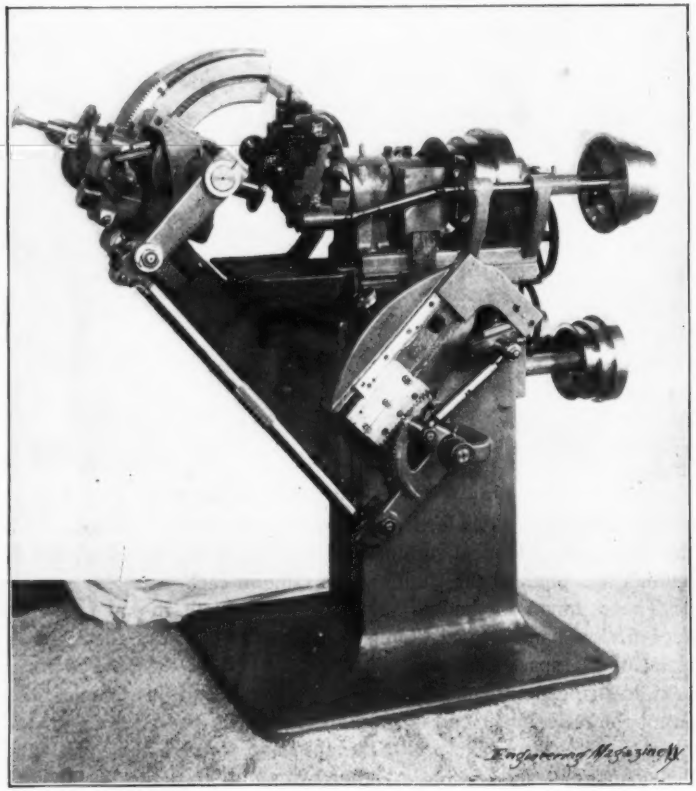


BILGRAM BEVEL-GEAR CUTTING MACHINES.

wheel; although, as before mentioned, correctly formed gear teeth can only have identical outlines in different wheels when both the number and pitch of the teeth are the same in each.

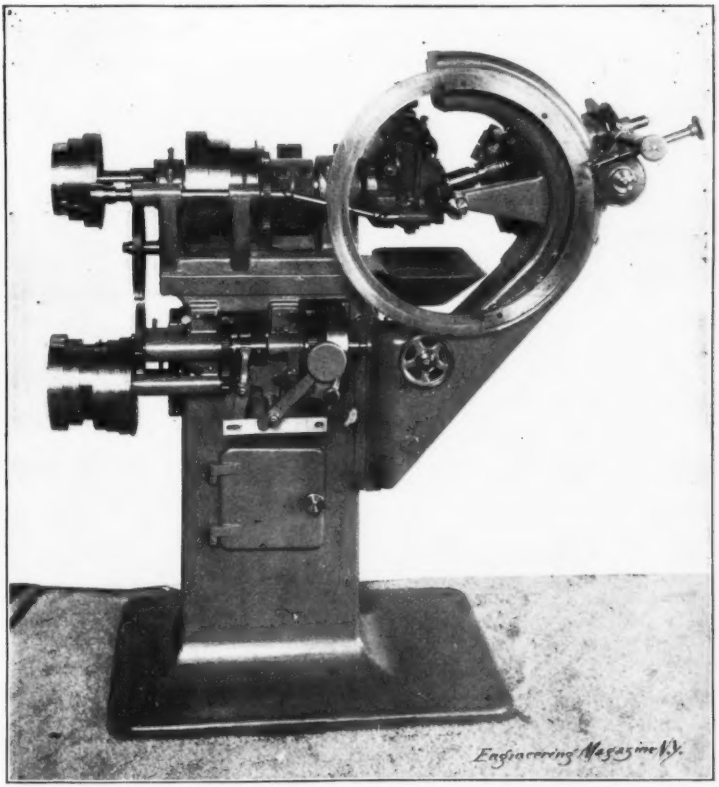
The common method of producing gear teeth to-day is to produce first a hand-shaped "templet," or reversed form in thin steel plate, of the space between two adjacent teeth of the desired form; next, to shape a cutter blank as nearly as possible to this templet; then to cut the teeth in the cutter and harden it; and finally, to cut a tooth space in the wheel blank with the cutter so formed, thus producing the opposed surfaces of two adjacent teeth. Then the wheel blank must be turned a certain distance exactly equal to the pitch of the teeth required, and held in this new position while a second tooth

space is cut. This method of wheel-tooth cutting is rife with possibilities of error from beginning to end. First of all, the cutter must be of the correct form for the precise number of teeth to be cut in the wheel; next, this form must be set exactly perpendicular to the cutter axis of revolution, not leaning to either side in the slightest degree. Then the cutter must not change its form in hardening, or else must be ground to its correct form after hardening. When the cutter is placed in the gear-cutting machine it must be set so that the mid-line of the cutter points exactly toward the axis of revolution of the wheel blank, and also so as to enter the wheel blank to precisely



WARREN BEVEL-GEAR CUTTING MACHINE. PRATT & WHITNEY CO.

Largely used in cutting bevel gears for the chainless bicycle.

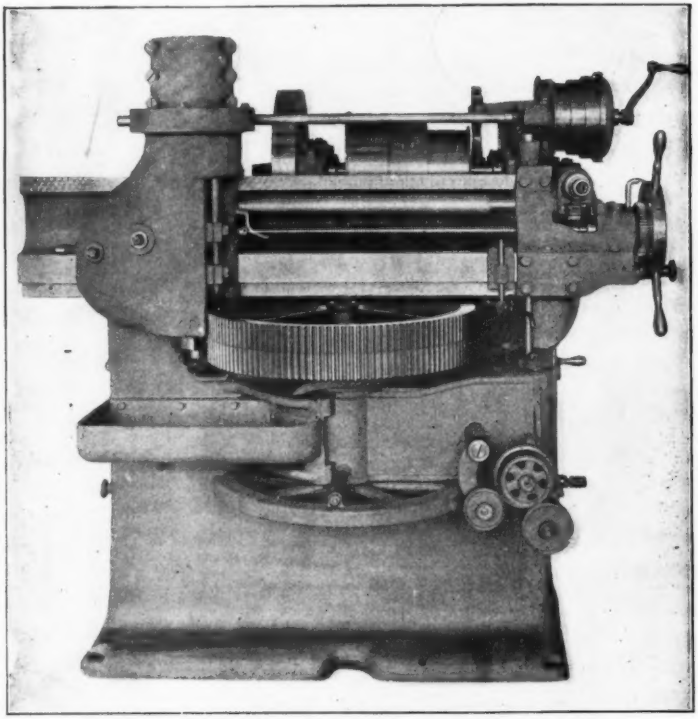


ANOTHER VIEW OF THE WARREN BEVEL-GEAR CUTTER.

the correct depth. Finally, the index plate or wheel, by which the blank is turned the right distance from one space cut to the next, must be perfect in its own spacing, since if it is not perfectly uniform some teeth will be thicker and some thinner than others. Again, as mentioned, each different number of wheel teeth demands a different shape of cutter, which is a commercial impossibility, because it calls for an unendurable cost in the great number of cutters needed for each different pitch of toothed gear produced. Hence it is customary, even in the best practice, to make a comparatively small number of cutters serve for all numbers of wheel teeth, from say twelve for the smallest pinion, to a rack or wheel of infinite diameter, eight different

cutters for each pitch being regarded as good practice, although it is quite impossible that any of the cutters except that for the rack should be of the really correct form, since all the others must be approximations to two or more different forms.

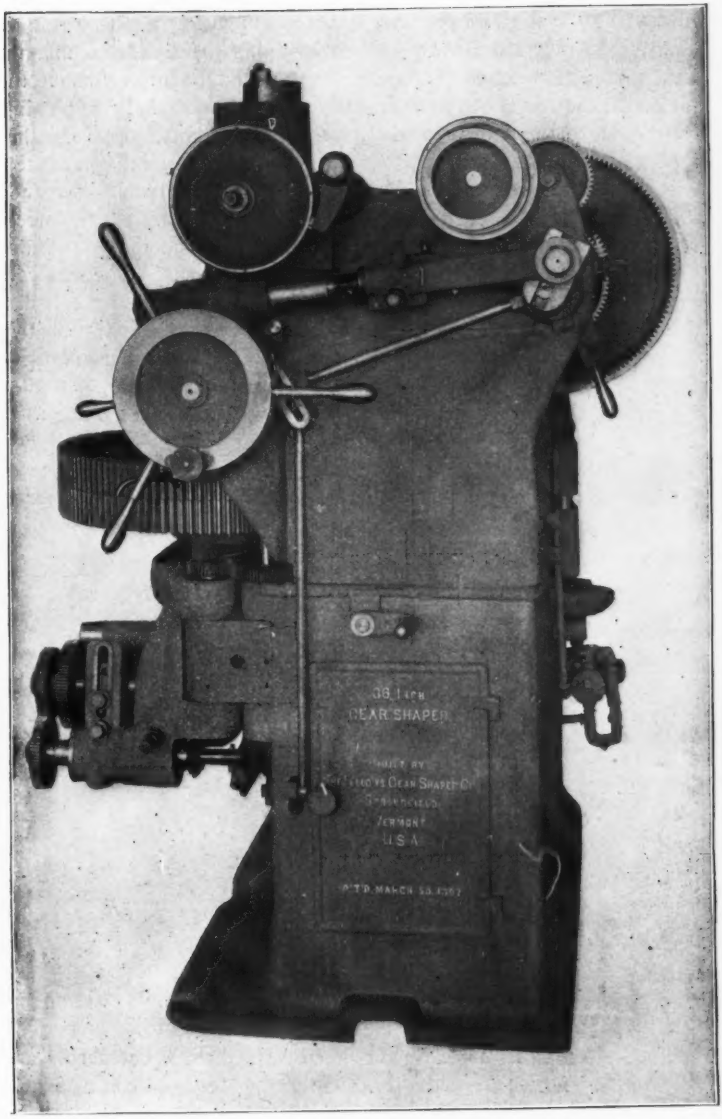
There are two distinct forms of gear tooth in approved general use, the epicycloidal and the involute; the epicycloidal gives the more nearly uniform driving impulse, provided that the two coacting gears



THE FELLOWS GEAR SHAPER CUTTING SPUR GEARS. FACE VIEW.

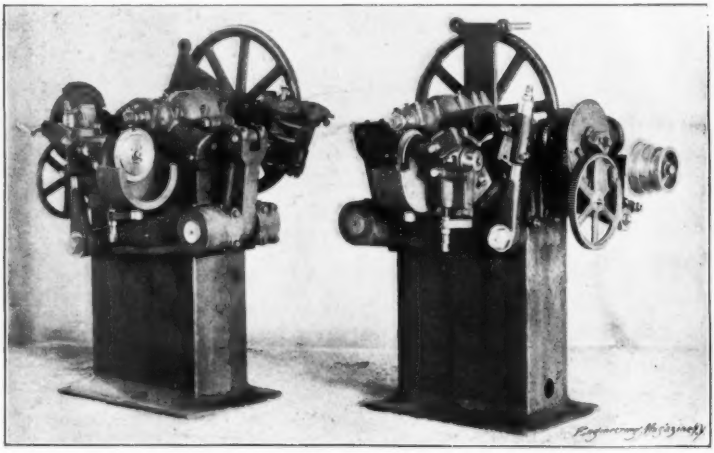
are perfectly accurate in dimensions and form and are also set exactly the right distance apart. The involute gear is less affected by an incorrect spacing between the axes, and has the additional advantage of having straight lines for the sides of its rack teeth, and because of these two peculiarities the involute gear tooth is more easily produced than the epicycloidal, and is in very general use.

The rack, or straight line of teeth, may be regarded as the founda-



THE FELLOWS GEAR SHAPER CUTTING SPUR GEARS. SIDE VIEW.

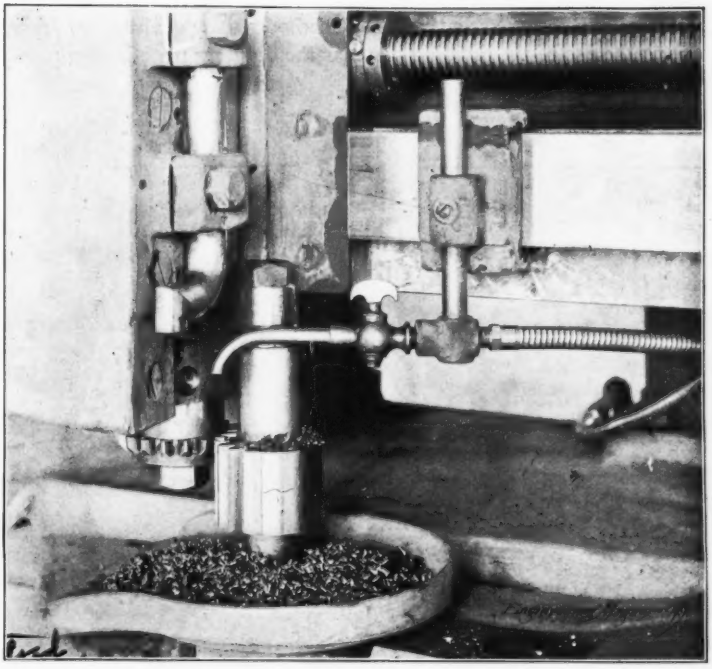
tion of any system of gearing, because, supposing a plastic pinion blank to be rolled at a uniform velocity along the rack, it is imaginable that pinion teeth of correct form would be produced on the pinion blank. Again, elaborating this fanciful and wholly impossible conception of the rigid rack and plastic pinion blank, supposing that a pinion with correctly shaped tooth is thus geometrically produced, without hand intervention and error, and that this pinion is hardened into rigidity; then this now unyielding pinion, if rolled at correct speed against another plastic blank of different diameter, would also produce correctly shaped teeth on the second blank, or would correctly reproduce the teeth of the original rack, if constrained to roll a plastic surface at the proper rate, in a straight line. The first person, so far as known to me, to entertain this wholly impractical flight of fancy was Christian Schiele, Oldham, Lancaster, England, who filed a provisional specification in the English patent office, Dec. 26, 1856, for "certain improvements in machinery for cutting nuts, screws, or bolts, and toothed wheels." Space permits but a brief notice of Schiele's gear-cutting methods. They involved the use of a "worm-hob," which is simply a short screw, made of tool steel, having straight



CUTTER-FORMING MACHINE FOR THE FELLOWS GEAR SHAPER.

inclined sides to its threads, and having its threads cut across and "cleared" to form an endless series of cutting teeth—all in a manner perfectly well known before Schiele's day, but previously employed only as a suitable cutter for forming the teeth of "worm wheels,"

adapted to be driven by a screw having its axis usually at right angles to that of the worm wheel. Schiele saw that by gearing a worm hob to the correct speed with a wheel blank, setting the hob at the correct angle, and then feeding the wheel blank slowly to the worm hob while

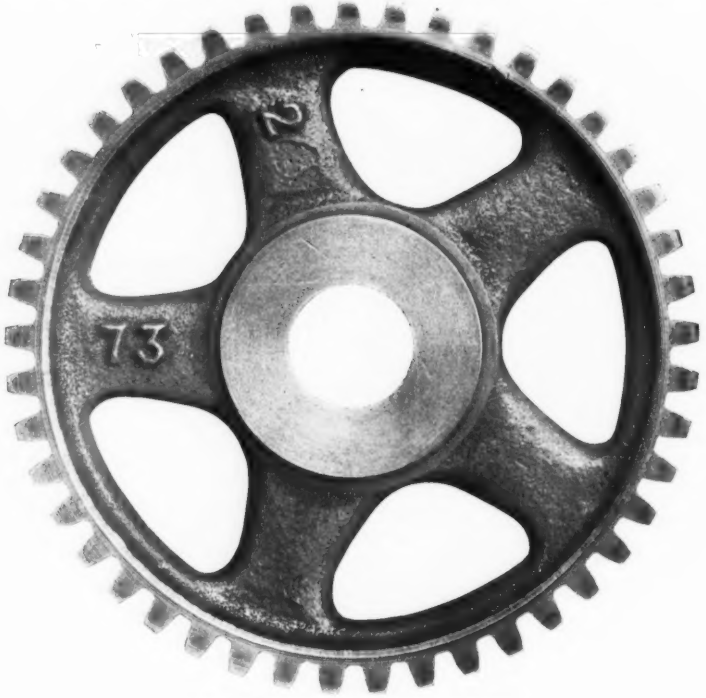


SHOWING CURLED CHIPS PRODUCED BY CORRECT CUTTER-FORM IN CUTTING STEEL GEARS.

both were revolving, the hob teeth would cut correctly formed teeth on the wheel, no matter what the wheel diameter might be, provided that the hob worm or screw was correctly shaped. Schiele's specification tells how to cut bevel gears with a succession of sinking cuts made worm-gear fashion with worm-hob cutters of different pitch, concluding by saying: "The joining of the different cuts will have to be made by filing to even surfaces." This is a very raw method of producing bevel gears, but Schiele's method of producing spur gears with a worm-hob cutter is perfectly correct and wholly practicable, although, so far as I am informed, two spur gears cut at the Pratt &

Whitney shops at Hartford, under the direction of Francis H. Richards, constitute the entire product of the United States of spur gears cut by this method. An engraving of one of the worm-hob cut spur gears is given below, photographed from one of these Richards wheels, loaned for the illustration of this article.

It will be observed that Schiele's method wholly obviates the errors due to the use of the dividing plate, as the dividing plate is eliminated.



A SPUR GEAR CUT BY SCHIELE'S METHOD.

It is, however, needful that the gears used to give the worm hob and the gear blank their relative speeds should be correctly spaced.

Schiele's claim on gear-cutting mechanism is as follows:

"And lastly I wish it to be understood that I do not claim the cutting of worm wheels as hitherto practiced, but I claim the method of obtaining a more continuous and correct cutting of other wheels, by using a divisional or regulating wheel' [meaning the gearing which gives the relative continuous

rotation to the hob and gear blank] "in connection with a worm cutter, so shaped and guided in its action as to produce the required forms of teeth independent of its tendency to act as a propelling screw or worm on the wheel; also the method of fixing and adjusting the larger kind of cutters" [inserted worm-hob teeth, keyed in] "and also the general arrangement and construction of such cutters, and the machinery or apparatus to be employed for cutting or trimming the teeth of spur, oblique, or other toothed wheels, as herein before described, fully set forth and exhibited by drawing attached." [Not reproduced here.]

In 1877 there appeared in the *Verhandlungen des Vereines zur Beforderung des Gewerbfleisses* a long article by Professor Hermann, of Aachen, discussing very completely the whole subject of the origination of theoretically correct tooth outlines by the relative movements of the gear blank and tool, and among the numerous illustrations accompanying this paper were shown simple arrangements of gearing by which any ordinary slotter or shaping machine could be used to produce teeth of either involute or epicycloidal shape, without templates or formed cutters. The machines and methods discussed in this paper are practically identical in principle and operation with those now in actual use, but it does not appear from Professor Hermann's article that he actually constructed or operated any gear cutters upon the principles so fully expounded by him.

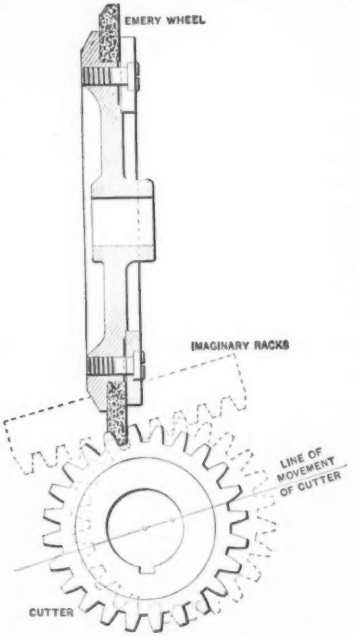
So far as I am informed, the first one in the United States to advance Scheile's general conception was Hugo Bilgram, of Philadelphia, who produced a highly ingenious and thoroughly practical machine of the shaper type, by means of which bevel gears are cut rapidly and with accurately formed teeth by the use of a rack-tooth shaped planing tool. Before this beautiful invention of Bilgram's there was no machine which could accurately generate bevel-gear teeth.

A very ingenious machine was designed by Mr. Ambrose Swasey, of the firm of Warner & Swasey, in which all the teeth of a set are generated at the time of cutting by the use of revolving cutters having the form of the rack tooth. The cutting tool in this machine is composed of a series of cutters rigidly connected; it revolves and at the same time moves longitudinally at right angles to the axis of the wheel to be cut, at the same speed that the latter is revolving at the pitch line, the motions being the same as in the case of a rack engaging with a revolving gear. This machine is fully illustrated and described in a paper by Mr. Swasey in the Transactions of the American Society of Mechanical Engineers, Vol. XII., 1890. It has been manufactured for their own use solely, and is not upon the market.

Barnes, of Rockford, Illinois, produced a machine in which bevel

gears of approximate accuracy are cut with spur-gear cutters, the different widths of cut needful for the bevel-gear space being obtained by vibrating the cutter from side to side, the arc of vibration decreasing as the cutter goes towards the smaller diameter of the gear blank.

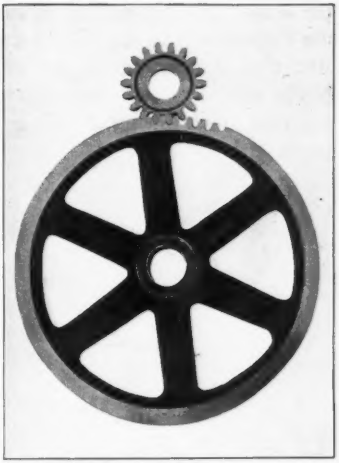
Warren, of Hartford, Conn., produced a very elaborate and thoroughly practical machine involving the vibratory method, which generates a correctly formed bevel-gear tooth by the use of a rectangular cutter.



The gear shaper built by the Fellows Company, Springfield, Vermont, generates correctly shaped spur-gear teeth by reciprocating an accurately formed cutter, finished to correct shape after hardening, across the face of the gear blank to be cut.

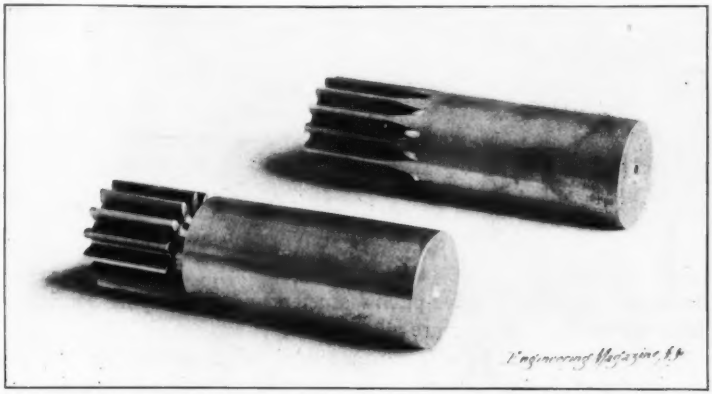
The "involute" rack, which may be regarded as a wheel of infinite diameter provided with involute teeth, has teeth with straight sides. The problem which Mr. Fellows set before himself was the geometric production of one single hardened tool-steel cutter, generated from an ideal and non-existent involute rack, which should accurately conform in its cutting contour to the lines of a pinion having the same number of teeth shaped to exactly coact with this supposititious rack. Above is a diagram of the method adopted for this cutter generation. The emery-wheel flat face represents one side of a tooth of the imaginary rack, the complete imaginary rack being shown in dotted lines. The face of this wheel is cut to a perfectly flat disk by a mechanically guided diamond tool. The cutter blank, previously roughed out and hardened, is then rolled past the revolving emery wheel with a true rack-guided pinion movement, the cutter blank passing the emery wheel with its teeth in precisely the position they would occupy if the emery wheel were one face of a tooth of a rack with which the blank was in mesh. This motion of the blank is ob-

tained by steel tapes wrapped about a disk of the pitch diameter of the cutter blank. While the cutter blank is making its revolving movement, the emery wheel grinds one side of each cutter-blank tooth to correct form, one tooth at a time, until all are finished on one side; then the half-finished cutter blank is placed in a second machine, of the opposite "hand," and the remaining tooth faces are similarly finished. The resulting cutter thus becomes a gear, the accuracy of which depends only on the true flatness of the emery-wheel disk and on the perfection of the rolling motion imparted to the cutter blank. Perfect accuracy can be obtained in both of these fundamental elements, and the resulting cutter is, in practice, one of the closest known mechanical approximations to theoretical accuracy. Only one cutter is needed for each pitch used.



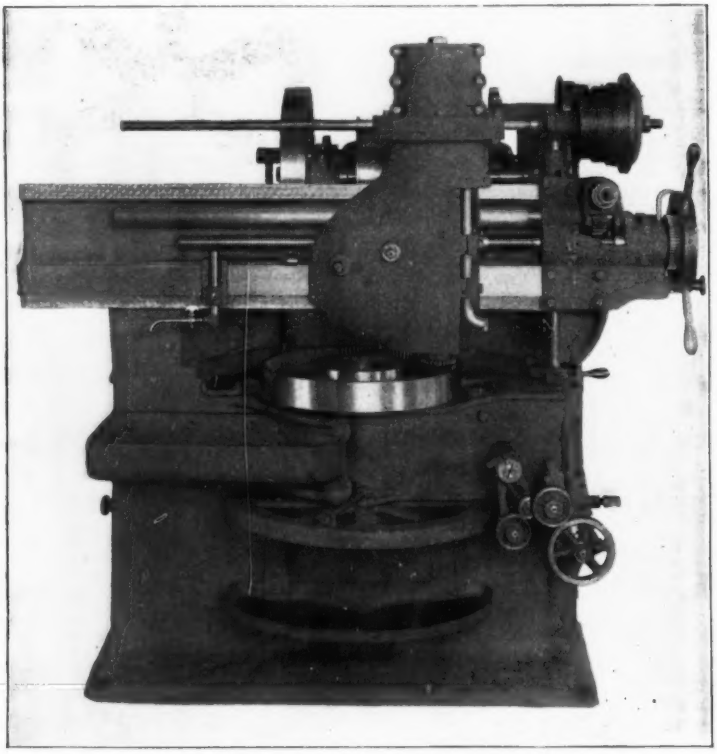
FELLOWS METHOD OF GEAR CUTTING.

The mode of gear cutting is shown above. The cutter is reciprocated past the face of the stationary gear blank in a line of travel parallel to the blank axis, and the cutter is gradually moved toward



THE LOWER PINION IS CUT ON THE FELLOWS SHAPER, THE UPPER ONE ON THE ORDINARY MILL.

the blank until its teeth have entered the blank to the proper depth, the cutter teeth having a face or top "rake" of 5 degrees, as well as side clearance, so as to give precisely the action of a well formed planer or shaper tool, and the cutter being moved very slightly away from the blank during the idle down stroke, and moved back into true position during the upward cutting stroke. As soon as the full depth



THE FELLOWS SHAPER CUTTING INTERNAL GEARING.

of cut is reached both the cutter and the gear blank are given the revolutions due to their relative pitch diameter, and the shaping continues until the teeth of the gear are all cut.

It is evident that by this highly ingenious procedure the teeth of each piece of gearing cut must be spaced with perfect accuracy, and must be given precisely the form required to coact with all other gears

cut with the same cutter, no matter what the diameter may be, which are the two most essential features of gear-cutting perfection.

Not only does this machine produce really correct tooth forms of machine-cut gear teeth, but the thinness of the cutter and the consequent very small over-travel required make it much more suitable for many important classes of gear cutting than those gear cutters using mills of ordinary form, as is shown on page 96, where the lower pinion is formed on the Fellows shaper, and the upper one has the straggling "run out" terminal cut, inseparable from the use of the mill. For the same reasons the Fellows machine is particularly adapted to the production of internal gearing, as shown on page 96. This very valuable and often extremely desirable form of gearing has hitherto been avoided by machine constructors, who would have been glad to use it if it could be readily produced. This machine cuts internal gears as readily and rapidly as it cuts spur gears, and can cut up to within a small fraction of an inch of the gear arms or web by using the pushing stroke, and to within a short distance of the arms when using the drawing cutting stroke. It operates also with much less strain on the gear blank and much less wear on the cutter teeth than in the case of the mill, as it starts each cut with the full cross-section of the chip, instead of starting on nothing as the mill-tooth cut must start, and rubbing along without a cut for some distance after it should be at work, before sufficient pressure is brought to bear to force the cutter into the body of the metal.

The Bilgram bevel-gear cutter, the Barnes, of Rockford, Ill., and the Warren, of Hartford, Conn., both for bevel-gear cutting, and the Fellows gear shaper for cutting external and internal spur gears, and the Warner and Swasey machine adapted for cutting spur gears only, form the only examples within my knowledge of irregular surfaces geometrically produced by compounding simple axial movements. It is possible that other machines of this character are in use, and there are some surfaces, those of some rotary blowing machines, for instance, which might well be formed by similar methods. But, as mentioned at the outset, irregular surfaces which demand accurate repetitions are very rare indeed in machine construction, and except in the one important case of gear teeth do not cover a field of wide interest.

ECONOMIC AND LABOR FACTORS IN THE DISTRIBUTION OF INDUSTRIES.

By John Richards.

THE geographical distribution of the manufacturing industries in future is a new subject. Its origin is in the prodigious changes in implements, processes, facilities of travel and transportation, and especially in scientific methods and the aggregation of capital characterizing the last quarter of the nineteenth century. In the near future it must affect the national polity of the various industrial countries, establish new lines of trade, affect many social conditions, and determine investments in productive enterprises, now reaching a scale so vast as to destroy the value of precedents.

Until very recently the distribution of industries has been determined by causes mainly accidental, not admitting of generalization. Development was tentative, capital was invested on accomplished facts, and was not expected to assume risks. Industries were mostly small, isolated, and included a personal factor. These small industries are now disappearing. Mental, manual, and even commercial skill are no longer the sole basis upon which productive industries are founded. These are necessary, of course, and in a greater degree than before, but all kinds of skill have become a commodity to be purchased, regulated by rules qualified by science, and directed in new channels or even transplanted from one country to another.

The possibility of a successful manufacture of any kind in a particular place is no longer a matter of accident or of local skill, empirical knowledge, or the predisposition of a people. At least, all these things have become weak compared with commercial incentive in localizing manufactures. The main question is, Where is the greatest difference between the cost of production and market value?

There is no romance in industry. It is trade, and amenable to the laws of trade. Commodities are produced for the difference between what they cost and what they will sell for. In this commercial age—the era of craze for luxuries that money procures—one must assume a

Mr. Richards' paper is especially interesting at a time when the "Trust" problem is undergoing so serious study. Sooner or later the futility of artificial restraints of trade will be recognised. Natural laws will assert themselves, in the economic as well as the physical world. The wise will not trust to the protection of a barrier which is certain to fall before the great forces of industrial evolution.—THE EDITORS.

purely commercial standard for all conjecture respecting the future distribution of industry.

With such a standard, admitting of computation and rule, it should not be difficult to predicate with tolerable certainty the circumstances under which future investments in industrial enterprises are likely to be made and the countries where certain industries will have their center and principal development. I say *future,* because in the past, as already remarked, the distribution of industries has been mainly from accidental causes of a local nature that would wholly fail at this time to produce the same results.

The heavy and dangerous processes—the heroic branches, they may be called—we find centering among the vigorous, unimaginative Anglo-Saxon people; the lighter class of products, involving imaginative traits, among the Latin races. This is equivalent to saying that accidental causes strong enough to found steel making in England would fail to do so in France or Italy. The making of porcelain wares at Dresden and Sevres, or of tapestry at Gobelin; diamond cutting at Amsterdam and wrought-silver working at Genoa; cloth weaving in Northern England and earthenware manufacture in Staffordshire—these are examples of the distribution of certain manufactures in which the principal component is local and even inherited skill. These industries have their origin to some extent in the predisposition of the people, but more largely in accident. There is no economic or commercial reason for such distribution; the causes were accidental, widely varying from what we can reasonably expect in the future.

It is not contended that all industries have been founded in this manner, but it is true of most of those in which skill is the principal component. In some cases this skill was progressive, inventive and changing, in other cases static or inherited. The writer once saw a workman with a simple tool cut external and internal screw threads on wooden screw faucets in a common lathe, using the tool by some peculiar sense of sight or touch to produce a true corresponding pitch for the screw and its matrix. In answer to an inquiry the man said: "I learned it from my father. It is easy enough"; but no one else could do such a thing without long training and the habit born of continual practice.*

Impediments to transportation, now to a great extent removed, have localized certain industries demanding heavy material and fuel.

* Screw threads are cut by "chasing" tools in metal working, but this is a different matter. The pitch is arrived at by experiment, tentatively, and is aided by the tendency of a multi-pointed implement to produce the pitch. In wood the threads are cut at one motion and the pitch is attained by some mysterious sense of the workman.

Others, consuming a great deal of motive power, have been centralized around its sources, either water power or cheap fuel. These causes must continue to act in future, but with diminished value. Many new conditions—cost and celerity of transportation for one thing—complicate even the apparently simple problem of the influence of motive power and contiguous material. English coal may be cheaper on the eastern side of the German Ocean than in the cities of England near where the coal is raised; pig iron may be cheaper in South American ports or at San Francisco than on the Atlantic seaboard, by reason of unbalanced freight and inward ballast loading; but in all these things there is a rule and method quickly discerned by those who invest capital in manufactures.

Among the components of industrial production none is so flexible and transferable as skill. The means of travel are so complete and the habits of environment and association are so easily broken off and renewed, that within a country having a common language and habits it does not matter much where skilled labor is required, it will soon concentrate at any point. We have continual examples of this at the present day, but only a short time ago if one wanted to conduct a skilled industry he must go to districts where the required skill was concentrated. The influence of localized skill yet exists and will continue, no doubt, but only in a weak degree except in some of the most difficult branches of manufacture and especially in the small and steadily lessening number but little affected by machine processes.

The founding of cotton manufactures at Bombay, India, and at Nagasaki in Japan shows how completely local skill is ignored when countervailing conditions are favorable. The use of unskilled labor in such cases is possible only in connection with machine processes. The effect of the machinery is not only to supplant manual skill, as is commonly supposed, but to establish a "rate of working." As a rule, the product of cheap labor is in proportion to the pay—or is less, when a rate is not enforced by machines. A machine attendant in Bombay has to do nearly the same work as one in Manchester, Lowell, or Rouen.

Industry can be divided into two classes; one involving special and progressive skill with constant change, such as the production of implements, instruments, and machines, the second producing articles of uniform character in which the quality is measurably fixed and invariable, such as cast and fibrous metals, pottery, and so on. In this latter class of industries the element of special skill may nearly disappear, and success may depend on economic conditions alone; in the former, success may depend upon excellence of design and adaptation, inde-

pendent of price. The money value of a cargo of iron, timber, or cloth, is determinable by the markets, but that of a cargo of machinery is not. This has a different standard of comparison. So it is with the causes distributing the production of these things; they also vary in their effects.

At this time a large quantity (about half a million of dollars' worth each month), of certain kinds of machine tools for metal working are being exported from the United States to European countries where the same machines can be made at a less cost for material and expense and perhaps, though it is doubtful, at less cost in labor. The reason for this trade in machine tools is not difficult to discern. It is a matter of skill in design and adaptation, joined with an organized and duplicated production, the latter enabled by an extensive and homogeneous home market that permits duplication or "manufacture" instead of "making." The cost of production is in this manner wonderfully reduced, while the efficiency and advantages of design have added to the price of American machine tools enough to transport and sell them profitably in Europe.

It is a peculiar branch of skilled industry to which the best skill is directed in all countries. These alone, among implements, produce themselves—that is, the machines are directed to the same processes that produce them, a thing not always thought of and one that lends a distinct feature of the trade. But to be permanent in future this trade must conform to certain inexorable conditions. Either the cost of their production must be less in the United States or their design and adaptation must be kept in advance. Considering the mobility of skill, the ease with which it flows from one place to another, and the widespread dissemination of descriptive technical literature, it is not reasonable to assume that this manufacture will remain an exception; it must in the end settle down to the lines of least resistance, that is, to the lowest cost of production. We can see signs of this in works of great extent and with the best possible equipment recently founded in Germany for producing machine tools on the American system.

Down to ten years ago the conservatism of practice in Europe and the want of the present widespread information formed a strong protection for American specialties in skilled production which found their way to European markets. American machine tools could be found in most parts of Europe, beginning with the small-arms factory at Enfield, in England, where many machines were furnished about forty years ago; but being demanded in small quantities and in special cases they found a market only in unexpected places. This sporadic

trade has now become extensive and is crystallizing into commercial competition. To maintain it, attention will soon have to be directed less to design and adaptation and more to the cost of production.

It was an early recognition of this principle that gave to Great Britain and her colonies at one time 49 per cent. of the commerce of the globe and extended her sway over nearly a fourth of the commercial world. This was not done by her internal industries alone, but by great wealth derived from an opposite policy in other countries where heavy imposts were levied on trade. The British bought out the subsidized industries and sent the subsidy to London. The French marine subsidies are a case in point. There is no doubt that the greater part of the vast sum paid yearly by the French government for building and operating vessels finds its way to England. Hundreds of millions of British capital are invested in various branches of industry in the United States to profit by a system that diverts American impost taxes to London. When the Swedes began making lucifer matches, paraffined and without sulphur or phosphorus, the great firms in London who had previously controlled the trade did not set about schemes to compete. They simply bought up Swedish works to an extent that supplied the trade, and continued to operate them.*

A tax on products of skill will perhaps find its sequel in international combinations among producers; but whenever this results the distribution of industry in various countries will be amenable to new laws—the inexorable laws of money and gain. Production will flow to the points of least resistance, and all local schemes for controlling industries must go down in the face of a commercial power that will ignore personality, patriotism, skill, and all kinds of individual effort. Without international combination, the control of prices for manufactured commodities is limited by those of the open market plus the impost taxes; but such limitation is not enough to satisfy its beneficiaries, as we can now see in the case of a proposed combination of the shipbuilding interests, now protected in the United States by "prohibition of imports." Ships are about the sole thing that cannot be purchased and imported by the people of the United States, and consequently they afford a fair example to show how far the idea of combination has pervaded the industrial world.

The struggle to maintain national industries by means of impost

* A fact, pertinent to the present subject, occurred about the same time respecting the trade in matches to Japan. That country had been supplied by Sweden, but when the trade began to be contended for by the English manufacturers of "Swedish" matches a few workmen and machines sent out to Japan soon settled the matter. I am informed that Japan does not import matches now.

taxes on home consumption, sending the surplus into the neutral markets of the world, cannot last long in this commercial age when, as now seems probable, industrial combinations will soon become international. Except in a few cases, corporate combinations have been content with controlling the domestic markets of their own countries by imposts and other means of discouraging consumers from purchasing in foreign markets, but anyone can see how this policy is weakening. The enhanced cost of all the components of production, due to augmented prices, raises the domestic cost of commodities above the world's standard, or above that of the neutral markets, so nothing is gained and foreign trade becomes possible only by discriminating prices between the home and foreign purchaser.

Under the distribution of industry such as will result from industrial combination and the expansion of carrying facilities the United States will beyond doubt have an enviable place—if the impost and navigation laws are modified to permit free exchange. In manufactures of metal and wood the natural resources are such that nothing but artificial values, and the instability caused by impost taxes, can prevent a first place in the markets of the world.

Shipbuilding, the distribution of which in future has recently called out a symposium of views in one of the leading English technical journals, will be an exception to other industries because of the construction of war vessels by and for goverments. The construction of commercial shipping is perhaps the most important of all the skilled industries and is a prize to be contended for among the nations. It reacts with wide influence on other industries and on the commercial polity of a country, and in future no doubt will be separated from the construction of war vessels and will follow the line of least cost.

In war vessels the circumstances are different. We have seen this industry center in Great Britain, partly by the influences of skill, but mainly because there has been a long era of peace in that country, a commercial policy that did not interfere with the industry, the greatest skill, prestige, and the lowest price for material. Most of these conditions will continue. It will be a long time before other countries will shift the incidence of taxation so as not to affect the value of material and other components entering into shipbuilding.

The natural price of extensively used commodities, when not interfered with by local circumstances, has become in a measure uniform. By natural price is meant the value fixed by the cost of production. All products have such a price, although it is common to hear it said that prices depend on demand and supply. So widely is this believed

that the saying has become an axiom. Yet it is a fallacy. A commodity never offered for sale, and for which there is no demand, must have a price. Such price—the natural one it may be called—is based upon the cost of production, as every one may see if he will trace out the genesis of prices. The "fluctuations" of prices are caused by demand and supply, and are unhealthy just in the degree that the demand price varies from the natural one.

In computing the cost of industrial production, it is common to estimate the labor component on the basis of a time rate, or per diem wages, without taking into account what the wages produce or what they will purchase in the country where earned. That this is fallacious goes without saying. Every carefully made investigation goes to show that the "rate" of wages is not at all a measure of the amount of wages that enter into the cost of producing.

As before remarked, the division of processes has ever been a characteristic of American skilled industry, and has in many cases diminished the labor cost of commodities below what could be attained in Europe even where the daily rate of wages was only half as great. Twenty years ago, the time rate of wages for making watches at Geneva was only a fourth as much as at Boston; yet the Boston watches had a lower labor cost. The difference is less now. At the same time a like but less difference existed in locomotive making. At the Baldwin Locomotive Works, in Philadelphia, 6.25 men made one locomotive in a year; at Berlin, in Germany, it required 13 men, at Paris 14 men, at Creusot 13 men, and at Crewe, in England, 11.5 men. The labor rate, it may be remarked in all these cases, is approximately inversely as the number of men; that is, is much the same measured by the product.

The wages of skilled labor are, in fact, a simple matter if divested of the sophistry thrown around the subject by confounding the "rate" of wages with the "amount" of wages, or, in other words, estimating wages by time instead of product. To make this plain one has only to confine the investigation to the practical conduct of any industry.

The part that trained skill may have in influencing the distribution of industry in future is not difficult to foresee. Its migratory character has been noticed, and this feature is all the time becoming more prominent as intercourse between countries becomes more intimate and extended. In a country geographically isolated as is the North American continent, and one that has applied not only the energy of its own people but absorbed it from other lands, people are not apt to realize how far the dissemination of skill has progressed in the older

countries. This is especially true of Great Britain. Her artisans go to all parts of the world. So do the Swiss, Germans, and Scandinavians, and of late years a great many American skilled workmen have emigrated to other countries, following their peculiar implements and founding advanced manufactures in special branches, in watch manufacturing in Switzerland for example.

There is not only emigration of skilled men to equalize the producing power in different countries; there are also internal causes at work tending to equalize advancement. To show how unstable are differences between countries in respect to industrial skill, people now living can easily remember when Germany was not classed among countries advanced in industrial production, nor even among those which competed in the neutral markets with products of skill; but twenty-five years have wrought a revolution. The elaborate system of technical education that, forty years ago, began in Germany and for a long time was considered an impractical method of reaching industrial production, because not supplemented with the manual skill and empirical elements existing in some other countries, now turns out to be foremost in exploiting trade in remote markets. Technical and scientific knowledge became plenty and cheap in Germany. It overflowed into all parts of the industrial world, soon gathering the art of practical manipulative processes and of making implements therefor, so that Germany, with a paucity of local resources in fuel, metal, and timber, stands fully abreast with her rivals. Education has done this work and forms a stable basis for it to rest upon in future. Her lexicographers have gone to Africa and compiled trade literature in the languages of savage tribes and have set at work various influences to promote sea trade. She has, without subsidies, greatly developed her merchant marine and in considering the future distribution of skilled industry Germany's share is a problem not easy to solve. As the skilled processes and implements of England, America, and France have reacted upon Germany, so has her educational system reacted upon these countries and others so that skill of head and skill of hand, with the organized system of industrial production, has become general, and is no longer confined to particular places as in the past.

It is reasonable to assume as a general rule that the permanence and stability of a manufacturing industry are inversely as the profits that arise from it, so long as such profits do not fall below a reasonable return upon the investment. There are, it is true, certain conditions which may seem to modify this rule, such as secret processes, patented implements, fictitious capital shares, and discriminating laws; but all

these are temporary, and must sooner or later go down before international competition. Profits on manufacturing are the same as interest on investments—the rate corresponds to the risk, and is so adjusted by experience and obvious economic laws.

The risk, or as we may say the danger of supersedure, is inevitable in any case where the profits of a manufacture rise above the normal rates of invested capital when the manufacture is open to international competition. The business may last a decade or a lifetime, but the end is no less inevitable and it is this fact that in many cases controls prices. In the manufacture of calcium carbide, for example, which in ten years has fallen from fifty to five cents a pound, the price has followed the cost of production and been regulated by international competition. Had the price been maintained at a high rate in any country, the industry would have become unstable and been superseded.

Profit is a regular component of industrial production, as much so as material, labor, and expense, and exercises a like influence on the permanence of a manufacture. Where it is declared and open, labor disturbance will cease among intelligent workmen, who know as well as their employers that this component must be supplied as well as their labor. Profits are declared and known in many industries in England and in some in the United States, with the difference, however, that in England the earnings are usually made up by an authorized accountant as well as by the owners. There is this check upon the accounts of all incorporated share companies, and the effect of this provision has been a great aid in maintaining skilled industries in a country where labor is especially turbulent and exacting.

The conclusions to be drawn from the cited conditions affecting the future distribution of skilled industry, and from many more that might be added, all point to an open struggle for supremacy during the first quarter of the next century, modified and hastened by combinations, or trusts as they are called in America. Local skill, traditional practice, personality, impost tariffs, and other circumstances that have in the past built up and localized industries, must succumb. Practice in the skilled arts will be assimilated, and the industrial nations assume a new and advanced position in world economy.

The opposing forces to this new system are legislative restrictions and the organized labor interests. The former have failed to deal with the problem, and the latter have developed no line of procedure that promises successful opposition to either industrial combination or distribution. The subject is one now undergoing investigation at many hands, but gives no immediate promise of a solution.

EDITORIAL COMMENT

Mr. Burt's comparison of the Nicaragua and Panama Canal projects was prepared some time since. The adoption later of the mean-level dividing-lock system, as recommended by the *Comité Technique*, has simplified and greatly improved the Panama route. The Bohio dam becomes comparatively an insignificant feature; the surface of the lake behind it will be only about sixty feet above the sea. A second small dam, at Alhajuela, confines a second lake, controlling and regulating the upper Chagres. On the other hand, the locks are differently arranged, being in two emplacements (Bohio and Obispo) on the ascent from the Atlantic and in three (Paraiso, Pedro Miguel, and Miraflores) on the descent of the Pacific slope.

Again, the former Walker commission is said to have recommended important changes in the Nicaragua route, which would involve changes of detail there. The results of the study of the United States Government commission, now examining the Isthmian Canal routes, may suggest further modifications of certain features. While these would involve considerable change of detail in an itemised comparison of the two projects, it is not conceivable that they would materially change the broad results of the comparison as to general advantages in feasibility of construction, ease of maintenance, cheapness, and convenience of transit.

The *prima facie* evidence in favor of Panama is extremely strong—and far more so because it is studied with absolute completeness and actually half completed. Nicaragua is a 'project," pure and simple, and so far a project based far too much upon foundation little better than guess work. It has not yet received the endorsement of any engineering talent even approaching in character that which has completely approved the Panama route. It has never won the confidence of capital sufficiently to support any serious effort at construction. And this scheme, devoid of authoritative engineering endorsement, incapable of inspiring financial backing, the people of the United States are asked to adopt blindly, to give their verdict for hastily, before the evidence they themselves have ordered can be put in.

It is, as the *Railroad Gazette* has said, competent to suspect the good sense or the good faith of those who urge such a course. The country will stultify itself and dishonour its self-appointed advisers if it act before their report is presented. Every board which has gone over the ground has urged the absolute need of such complete study as the present commission is making, before an intelligent conclusion could be reached. A million dollars has been appropriated for this adequate study, and now frantic effort is being made to force a conclusion before the results can be presented.

The case should not be prejudged either way; but the Panama Canal is at least an actual entity—thoroughly studied in every detail, fully endorsed as practicable by unimpeachable and impartial authority, closely estimated as to cost, half finished and fullly equipped for complete execution. The Nicaragua Canal is "three-quarters of a mile of * * dredging in the low swampy ground." about twelve miles of rails laid on felled trees, with an equal length of telegraph wire strung on standing trees, a once-dredged but since filled-up channel on the foreshore at Greytown —and a strong and persistent influence in the lobbies of Congress and the platform committees of the great political parties.

As indicated in the editorial note appended to the valuable article of Professor Stodola upon steam engine building in Switzerland, published in the last issue of THE ENGINEERING MAGAZINE, lack of time prevented the submission of the translation to the author for examination and revision. We are therefore pleased to place these columns at his disposal for the insertion of a few additions and modifications which have since been received from him.

Professor Stodola is of the opinion that notwithstanding the increasing demand for power in Switzerland, the steam-engine manufacture is likely to diminish somewhat in volume, with the increasing development of water power, and that much of the future business will come from export orders.

The peculiar arrangement of the cylinders in the Sulzer horizontal tandem compound engines, the high-pressure cylinder being placed behind the low-pressure, diminishes the influence of the heat in causing deformation of the working parts.

In this connection Herr Emil Mertz, of Basle, calls attention to the fact that his firm not only constructs engines from the designs of Mr. C E. Brown, but also builds compound and triple-expansion engines of his own design.

* * *

It has long been felt among engineers in the United States that the Patent Office has been a sadly neglected department of the government, and the recent expres sion of opinion of the American Society of Mechanical Engineers but calls attention to that which most of its members have known for a long time.

Notwithstanding the fact that the receipts are largely in excess of its expenses, the balance in favour of the office being more than $5,000,000 in 1899, business is hampered and delayed by reason of an inadequate force of examiners, insufficient space for work, and a general lack of proper facilities. The library is by no means what it should be, and even such as the collection is, it cannot be used to advantage because of the contracted quarters in which it is housed.

It must not be forgotten that the records of the Patent Office constitute the legal evidence of title to a most important portion of the property of many great manufacturing establishments engaged in the production of patented articles. Many of the important suits in the United States courts deal with the rights of patentees and their assignees, and yet the records of this great industrial department of the government are neglected, in a manner which should cause the persistent demand of the whole industrial community for its remedy.

* * *

It has generally been supposed that technical and scientific societies were formed for the purpose of disseminating as widely as possible the latest and most reliable information in the various departments of work to which they belong, and in most cases this is true. Papers are printed in advance and distributed to the membership and also to the technical press, and usually the only limitation placed upon republication is the requirement that reprints shall not be made until after the communications have actually been presented before the organisations for which they were prepared. There are, however, a few societies on each side of the Atlantic which still adhere to the policy of declining to give out advance copies of their transactions to the technical press, and even forbid full reprints after the public presentation of the papers. Such action can do the organisations themselves no good, and can in the end only act to repress the presentation of really valuable papers, authors themselves always preferring to reach as wide an audience as possible; while the effect upon the technical journals is rather to excite feelings of sorrow that the ancient idea of the exclusiveness of knowledge still has a few followers in the midst of the modern appreciation of the great truth that "there is no darkness but ignorance."

REVIEW OF THE BRITISH PRESS

Railway Communication with India.

THE general development of railway enterprise in various parts of Asia lends interest to the paper of Mr. J. M. Maclean upon new projects of railway communication with India, recently read before the Society of Arts, and published in the *Journal* of the society.

Mr. Maclean begins by referring to the history of trade with India from the time of Marco Polo and the overland caravan route, down to the discovery of the route around the Cape, and the opening of the Suez canal, showing how the wealth which flowed into Europe from trade with India has influenced the course of commercial and political events in all parts of Europe.

The opening of the Suez canal permitted other nations than England to compete for the Indian trade and has seriously reduced the profits formerly controlled by England.

"Now it would appear that a new economical and commercial revolution is impending, and that maritime commerce is threatened with serious competition from the new trans-continental railways which Russia, in particular, is constructing with so much energy and foresight across Asia."

The completion of the Siberian railway and its connections to China will flood Asia with Russian and German commercial travelers, and a great proportion of the traffic which is now conducted by sea will be transferred not only to the overland route, but to the hands of England's competitors. The plans of Russia are not limited to the Siberian railway. A branch from the main line has been projected and surveyed which will extend from Orenburg to Samarcand, this completing, by a junction with the Trans-Caspian railway, the iron girdle with which all central Asia will be embraced by Russia. This will offer a tempting opportunity for the further progress of the railway through Afghanistan to Peshawur, and for that linking-up of the Russian and Indian railway systems which would reduce to nine days the journey from London to Calcutta.

The engineering difficulties in the way of this work are not great, and it would involve nothing more than the construction of a very few hundred miles through the passes of the Hindoo Khoosh and the Himalayas. It has been suggested that a better route would be by an extension of the branch of the Trans-Caspian railway now open to Kushk to Chaman, below Candahar, which is the terminus of the Indian railway system This line, however, would debouch into India at its extreme western limit, and would be complicated by the break of the Caspian Sea, across which passengers and goods must be conveyed by steamer. The line through Orenburg, on the contrary, furnishes unbroken land communication from Calais to Calcutta, and avoids both the Caspian and the sea of Aral, and possesses unquestionable advantages over any other that can be named.

It does not appear that England's oversea commerce with Bombay can ever be seriously interfered with by railways, but there is competition to be feared from a through land-line from Calais to Calcutta, which would enter India near its centre, and be continued down the great valley of the Ganges.

All these railway projects afford evidence of the immense commercial activity now spurring on both Germany and Russia to new enterprises. The rivalry of Germany has become generally appreciated, but less heed has hitherto been paid in England to the prodigious industrial and trading development that has taken place in Russia. It is generally assumed that the Trans-Siberian railway has been intended mainly for military purposes, but while that is largely the case, it is more correct to say that the commercial importance of the road holds the first place. The migration of Russian peasants to settle on the country opened by the new line has already begun, and a hard working agricultural population is settling down in what were the waste regions of Siberia. This emigration is encouraged and assisted by the government,

houses, land, and implements being furnished free, and taxation for several years relieved, so that a permanent connecting link will be formed between Russia and Northern China, and an important trade ultimately be developed.

It is the idea of Mr. Maclean that the British government should secure its share of control of railway communication to India by joining with Russia to compel the Ameer of Afghanistan to permit the construction of railways throughout his kingdom. Everything is ready for an extension of the Indian railways from the terminus at Chaman, on to Candahar, this work only being checked by the position of Afghanistan. If this connection were made, Calcutta and Kurrachee would become the seaports for Russian goods desiring an outlet on the Indian Ocean, and India would be able to conduct a large and lucrative trade in her own articles of merchandise with the Persian and central Asian markets. Any objection to the linking up of the Indian and Russian railways might be equally well urged against the connection of railways on the Continent of Europe, and no one would desire to disconnect the railway communication between Paris and Berlin because war may some day break out again between France and Germany. Preparations for war between Great Britain and Russia need not be more formidable if the two empires are no longer separated by a belt of neutral territory, if both Powers well understand that the first step beyond a fixed line is equivalent to a declaration of war. There appears to be no good reason why a different rule should hold between two civilised nations in Asia than in Europe.

The Standardisation of Electrical Plant.

THE paper of Mr. Percy Sellon, read before the Institution of Electrical Engineers, upon the standardisation of electrical engineering plant, contains many valuable points upon this much discussed subject, especially since it does much to clear up the objections which have been urged against any change in the present practice.

Mr. Sellon calls attention to the fact that repetition manufacture is as important a factor in successful competition as cheap labour, cheap material, and efficient management, and shows that it has been the adoption of standard designs and methods which has rendered the powerful competition which England is experiencing with Germany and America a possibility.

The cause for the difference in the practice of engineering in England and her competitors is largely due to the different position held in different countries by the consulting or designing engineer.

"According to American and Continental practice, the producer determines, in a large measure, the character of the plant employed by the user; while according to British custom the buyer very generally imposes upon the manufacturer not merely a specification of the ends which he wishes to attain, but the details of means by which he desires those ends to be achieved.

"This is due to the fact that under the American and Continental system producers largely secure outlets for their manufactures through the agency of powerful financial organisations created by and allied to their interests, who are concerned simply with commercial results, and are content to leave the technical means of attaining them to the manufacturing interests with whom they co-operate. In America these organisations take the form of colossal trusts or consolidations of competing interests; on the Continent that of industrial banks. In either case there is a close relation between producer and buyer.

"In Great Britain, on the other hand, the demand for electrical engineering plant in recent years has issued chiefly from local authorities, or from private users unconnected with any manufacturing interests; and these have very naturally had recourse to electrical engineers acting in a consulting capacity or passing permanently into their service, to guide them in the choice of plant to fulfil their requirements."

It is thus evident that in England the engineer is employed by the purchaser, while elsewhere he is employed by the manufacturer.

It is entirely natural that this difference in practice should result as it has. The manufacturer demands of his engineer that he should design work which shall not only be efficient in operation, but also profitable in manufacture, and standardisation follows as a matter of course. The engineer employed by the customer, on the contrary,

makes his designs before it is determined by whom they are to be executed; and in any case rather prefers not to imitate or follow details of the practice of others.

At first sight it might appear that either method would produce good results, but there is one point of which sight must not be lost: the buyer's engineer has gradually overstepped the rational function of stating the ends or performance required by the buyer, and has proceeded to specify in minute detail the means or constructional methods by which the required results are to be achieved, without taking responsibility for the result.

When the engineer is responsible to the manufacturer, not only for the successful performance of the product, but also for the possibility of its economical manufacture, he is not apt to try too many experiments or to endeavour to infuse too much individuality into the work, but will retain well proven and standard methods and details, and in many cases bear in mind future uses to which various parts may be put.

It has been maintained that standardisation must act to retard progress and to prevent the prompt introduction of improvements, but experience has shown that the most rapid progress is made in those countries in which standard designs are most used, and it is evident that competition between manufacturers will always prevent any such stagnation. Retardation is much more likely to occur by reason of the multiplicity of designs and methods resulting from the exercise of unrestrained individuality.

Mr. Sellon makes a suggestion as to the best method of obtaining the benefits of standardisation without abandoning the services of the buyer's engineer.

"Assuming," says he, "that the buyer's engineer has come to stay, it would appear that a condition precedent to the standardisation of plant is the standardisation of the buyer's engineer.

"The initial obstacle to a greater measure of standardisation than at present obtains would be removed if the user or his engineer would confine himself to stating the ends he has in view, leaving it to the producer to furnish the means whereby they may be attained. If this procedure were adopted, users would still retain full liberty of choice between the products of different manufacturers, while the latter would have an opportunity (which under the present system of detailed specifications they do not enjoy) of undertaking repetition manufacture, assuming that they have sufficient confidence in the substantial harmony between their designs and public requirements to take the risk of quantitative production."

If there were any doubt as to the necessity of standardisation in Great Britain, it would surely be removed by an examination of the table appended to Mr. Sellon's paper, in which is shown the system, periodicity, generating pressure, and distributing pressure in the central stations of Great Britain. The entire absence of anything like standard practice, and the presence of trivial differences, will prove, if proof were needed, that great advantages might have resulted from a little harmony of action between designers and manufacturers.

Progress in Space Telegraphy.

THE recent address of Mr. Marconi before the Royal Institution, while largely popular in its nature, is worthy of note as the latest account of the progress which has been made in space telegraphy, and hence a brief abstract is here made.

In the apparatus itself some important changes, or rather modifications, have been made, which appear to improve its action very materially. In the coherer the principal change has been the marked reduction in the distance between the terminals. The early coherer consisted of a tube several inches long, partially filled with filings enclosed by corks, but this construction was not altogether reliable. If, however, specially prepared filings are confined in a very small gap, say about one millimeter, between flat plugs of silver, a much more reliable instrument is obtained. The resistance of such a coherer is practically infinite when in its normal condition, but when influenced by the electric waves it instantly becomes a conductor, the resistance falling to 100 to 300 ohms, and remaining so until the tube is shaken or tapped.

The other improvement is also important. Instead of connecting the vertical and earth wires at the receiving stations directly to

the coherer as formerly, Mr. Marconi now connects them to the primary of a small induction coil or transformer, the secondary of which is connected to the ends of the coherer, one of the connections passing through a condenser. The effect of this transformer is to increase the electromotive force of the induced oscillations at the terminals of the coherer, and to cause it to break down with a weaker oscillation than would be possible if it were connected directly to the vertical conductor. This renders it possible to communicate over much greater distances than formerly, a most desirable result.

Mr. Marconi discussed at length the peculiar windings which he found necessary for the induction coil used by him, showing that unless this matter was most carefully attended to no effect would be produced. The effect of the peculiar mode of winding, for which the reader must be referred to the diagrams of the original paper, is to prevent the effects due to electromagnetic induction from being in opposition with the electrostatic induction at the ends of the primary.

The later experiments have practically verified the correctness of the law previously announced as to the distance over which signals might be sent. This law is that the distance over which it is possible to signal with a given amount of energy varies approximately with the square of the vertical height of the wire, and with the square root of the capacity of the plate, drum, or other form of capacity area which may be placed at the top of the wires.

Many months ago it was found possible to communicate from North Haven Poole to Alum Bay, a distance of 18 miles, with a height of 75 feet. It has now been found that with wires 150 feet high communication can be effected from Wimereux, in France, to either Harwich or Chelmsford, the distance in either case being 85 miles. According to the theory, doubling the height of the wire should give four times the distance, or 72 miles, but it appears that the law is only approximate, and that the tendency is on the side of a slight excess in range. It is especially interesting to note that the height of the poles at the stations was but 150 feet, although it would have been necessary to have had vertical wires of over 1,000 feet in height for a straight line between them to have cleared the curvature of the earth.

Mr. Marconi made some remarks about the use of his apparatus in South Africa, showing that it was of little service, owing to the lack of provision of poles for the vertical wires, although some successful experiments were made with the aid of kites.

Predictions are always uncertain, but Mr. Marconi claims that the progress which will be made this year will greatly surpass what has been accomplished in the past twelve months, and maintains his belief that, by means of the wireless telegraph, telegrams will be as common and as much in daily use on the sea as at present on land.

The Quality of Steam.

In the course of an editorial discussion of the important subject of the quality of steam, *The Engineer* brings out some interesting points, especially in connection with superheating.

It is rightly claimed that not enough attention is given to the quality of steam produced by boilers in the ordinary course of power generation, but that in most cases it is moist, and in some instances it is very wet. Calorimeters are used during tests, especially if any requirement as to dryness of steam has been specified, but after that but little is thought of the quality of the steam, and unless enough water is carried over to cause trouble in the cylinder, but little attention will be paid to it. A much smaller quantity than that necessary to cause a breakdown may still do much harm. Piston rings may be broken, packing ruined, valves jammed, even by clean priming, while the dirty stuff which is carried over from some boilers is responsible for much cutting of valve seats and scoring of cylinders.

The most obvious remedy for wet steam is superheating, but this will not prove a complete remedy unless it is accomplished intelligently. It is not good practice to permit a boiler to prime freely and then obtain dry steam by providing an abundance of superheating surface. The superheater becomes a sort of auxiliary boiler, and works under all the disadvantages of a

boiler with an insufficient supply of water. Unless the water is altogether free from lime and other salts there will be a deposit of scale in the superheater, and if the superheating is carried to a fairly high degree there will be formed, instead of scale, a fine hard dust of lime and iron rust, which will be carried along with the steam into the engine, scoring and cutting the valve seat and cylinder in a marked degree.

Excessive priming should be prevented by proper boiler design, ample capacity, and the use of clean and pure water, and the saturated steam thus produced then passed into a superheater to be given such a degree of excess temperature as will prevent to a great extent the losses due to cylinder condensation.

Instead of performing the superheating altogether before the steam enters the engine, it may, in the case of multiple-expansion engines, be done in the receivers. Live high-pressure steam, circulating in coils in the receivers, will provide dry or superheated steam for the intermediate and low pressure cylinders, and all the heat thus supplied from the boiler will be returned in the form of useful work, while the action of the steam in the later cylinders will be improved, and this method is now advocated by a number of successful builders. It has also been suggested that some liquid of a high boiling point, such as oil, might be used in a system of circulating pipes to convey heat from the boiler flues into the receivers, thus enabling heat which would otherwise be wasted to be used instead of employing live steam.

Whatever method be employed, there can be little or no doubt that clean, hot, dry steam is necessary if the highest economy is to be realised, and it may be accepted that the immediate practice of the best makers is tending strongly in the direction of fairly high superheating as a necessity. That this will involve some modifications in constructive details must also be admitted. Sliding valves, whether of the flat, piston, or Corliss types, are not well adapted for use with the hot dry gas, and poppet valves with lift and drop movement appear to be the most available. This has already been demonstrated in the analagous practice of internal combustion engines, and it is well-known that prominent builders are preparing to modify their standard designs with a view of rendering their engines suitable for use with highly superheated steam.

In discussing the highly economical results which have been announced as performances of engines operating with superheated steam, care should be taken to ascertain that all the costs properly chargeable to power have been included. If a separate superheater is used, the calorific value of the fuel burned in connection with it should be charged to the engine in computing the efficiency, and all steam supplied to jackets or receivers should be included.

As matters now stand it is very difficult to make intelligent comparisons of the performances of various engines, owing to the varying conditions under which the trials have been made, and the incompleteness of the data and results given to the public. It is to be hoped that the efforts of the committees of the Institution of Civil Engineers and the American Society of Mechanical Engineers, which have this important matter under discussion will result in the general use of methods which, while sufficiently flexible to permit of adaptation to all practical cases, will at the same time insure the determination of the data which may render the results in all instances consistently comparable.

Gas as Fuel.

THE advantages of gaseous fuel have frequently been set forth, and in respect of cleanliness, convenience, and freedom from smoke it leaves nothing to be desired. The question of the economy of converting coal to gas in a producer and using the producer gas as fuel, should, however, be determined by a comparison of the results which would be obtained if the same fuel had been burned directly in a furnace. The method of making such a comparison is very clearly given in an article in a recent issue of the *Iron and Coal Trades Review*, from which an abstract is here given.

In the conversion of coal to gas in a producer an indirect or partial burning takes place, and this burning has generally been considered to occasion a loss of about one-third of the heating power of the coal, this conclusion probably being based upon the fact that carbon burned to carbonic

oxide parts with 30 per cent. of its heating power. While this is true as to the fixed carbon in the coal, it is not correct for the volatile carbon, which, so far from losing heating power, becomes rather the absorbent of much of the heating power the fixed carbon loses.

In order that a fair comparison may be made, the action of burning coal in an ordinary furnace should be considered.

"Before the first appearance of flame can kindle on a piece of *ordinary* coal, heat must have been absorbed and work done upon that piece. This work is the liberation of gas and vapour out of its solid mass. The change in volume which takes place on the gas and vapour substances so liberated is very great. A single cubic foot of coal may yield several hundreds of cubic feet of gas and vapour, and this too while the coal to outward appearance is suffering no diminution of its own bulk. Such a change in volume in any body has a close connection with the amount of heat which must disappear in working the change. Of the whole substance of the coal there is usually about one-third, in many cases a good deal more, over which there passes this great change in volume. From this it will be seen than heat absorption on a scale too great to be overlooked has to be reckoned with in the combustion of a lump of coal."

When the combustion takes place in a producer it is that of the fixed carbon of the coal, burning to carbonic oxide, the carbon being dissolved away from its solid form into a fluid, combustible gas, only the incombustible ashes remaining. From the heat produced by this burning is supplied whatever part may be necessary to drive out the vapour and gas. Whatever moisture may be present in the air supplied is decomposed, but the heat absorbed in this action is restored by its subsequent recomposition.

Having considered these actions it is possible to make a comparison between the effect of the direct combustion of fuel with that produced by its conversion to gas in a producer previous to combustion.

As an example, Lanarkshire splint coal is taken as a fair representation of the common manufacturing coals of Scotland, and for 100 units, burned in an open fire grate, it is shown that there would result 548,733 calories, making deduction for the heat expended in expelling the gaseous matters. The same coal converted into gas is a producer, the gas being subsequently burned cold, would evolve 493,924 calories, thus showing a loss of but 9.98 per cent. by burning it as producer gas. Approximately similar results are obtained by taking an average of the coals of the whole United Kingdom.

When the coal contains very low fixed carbon and a corresponding high proportion of volatile carbon there would be no loss whatever in the conversion into gas, while for anthracite there would appear a loss as high as 25 per cent., or even more.

With such fuels as the shales the proportion of volatile carbon is so high that it would be entirely possible to mix a shale with anthracite in such proportion that no loss would appear by conversion of the mixed fuel to producer gas.

As it has been proposed to conduct the gasification at a sufficiently high temperature to fuse the ash to a slag, in order to prevent clinkering, and to facilitate the removal of the non-combustible, it is interesting to see that the computations show a loss of less than one-half of one per cent. of the full heating power of the coal for each 5 per cent. of earthy matter fused to liquid slag.

It appears then that in making producer gas with coal of average quality, the loss in heating power need not be much over 10 per cent., and that this 10 per cent. of loss may be wiped out by certain changes in the fuel.

The Functions of the Engineer.

THE address of Sir W. H. Preece before the Glasgow Association of Students of the Institution of Civil Engineers upon the subject of the functions of the engineer contains some excellent points which call for emphasis and comment.

After distinguishing the civil engineer, or practical man of peace, from the military engineer, or practical man of war, he goes on to show how far-reaching the scope of the work of the civil engineer may be extended.

"The success of the modern engineer is due to the fact that he has buried in the depths of oblivion the much vaunted empiri-

cal rule-of-thumb, and that he has elevated to the heights of science the observations of exact practice and the exercise of pure reason. The principle of doubt, which is the root of all scientific inquiry, forces him to consider every phase of weakness in the materials that he employs in his structures, to examine every possible cause of error in his designs, to anticipate every source of failure in his work."

As a result of this modern advance in the application of science to practice, the education of the engineer has become a matter of ever-increasing importance. The modern engineer is the outcome of high-class and long-sustained education, either imparted or self-acquired. Such an education is obtained not only by the study of books and the hearing of lectures, but also by the cultivation of the powers of observation, the systematic training of the memory, and the development of the exercise of thought.

Engineering has now become only another term for applied science, and in order that the engineer may properly fulfil his functions in the modern conditions of work he must know how to apply science in the truly practical form.

"The boy who has passed well through the ordinary curriculum of school, and proceeds thence into a university, from which he emerges as a young man not only well imbued with the refining influences of literature and art, but with a well-earned degree of science, is fully prepared to commence his engineering training and to enter the workshop or the drawing office, where alone he can acquire that combination of knowledge and skill, and that training of the brain and the hand for mutual aid which is called technical training.

"It is not a question between science and practice; it is a question between science and rule-of-thumb. Practice is always there, but rule-of-thumb means rule of error, until by repeated failures rule-of-thumb becomes rule of right, which means the victory of organised common sense. Organised common sense is a very good term for science. Scientific men talk nonsense when they observe differences between science and practice, and so-called practical men act foolishly when they ignore science and assert that an ounce of practice is worth a ton of theory. Practice based on true science means immediate success and economy; practice based on rule-of-thumb means error, delay, and excess of estimates. The engineer cannot neglect the laws of nature any more than the scientific man can ignore the success of practice.

"The civil engineer of eminence has not only to know thoroughly the science, but also how to conduct the practical operations of his profession. The lives of human beings are entrusted to his designs. People have faith in the safety of his ships, long tunnels, bridges, and railway trains. He is called upon to advise on policy, to deal with commercial management, to act as arbitrator or judge in many important judicial cases, and to appear in courts of law and committee rooms of Parliament as an expert witness. The mental qualities of the engineer must therefore be of the very highest order. His scientific training and his world-wide practice have broadened his views and enlarged his mind. Above all, his character must be above reproach. The honor of the engineer is the honor of his profession."

Aerial Propellers.

ONE of the most important questions in connection with aerial navigation is that of the resistance of the air, both as an obstruction to the motion of bodies passing through it, and when considered as an abutment for the reaction of propellers. The experiments of MM. Le Dantec and Canovetti were discussed in these columns several months ago (October, 1899), these relating to the resistance of the air to falling planes and to moving bodies in general, and now we have in *Engineering* the paper of Mr. William George Walker, giving the results of his experiments with large propellers.

The experiments, which were carried out during the latter part of 1899, with the expert and financial assistance of Mr. Patrick Y. Alexander, were made to determine the thrust or lifting power of air propellers 30 feet in diameter. The author had previously made experiments with propellers varying from 2 to 5 feet in diameter, and in a communication to the British Association at its meeting at Bath, in 1899, he showed that for tip speeds up to 15,000 feet

per minute the thrust varied as the square of the speed, and the horse power varied as the cube of the speed. Making some allowances for experimental errors, these laws have been followed in the case of the 30 foot diameter propellers.

In the report of the experiments made to the Royal Society, from which the author had also been aided by a Government grant, the apparatus is very fully described, and only a condensed account of it can be given here. The propellers, of which there were several tried, were mounted on a horizontal axis at the end of a room 68 feet wide, 60 feet high and 210 feet long. The propellers were arranged to be driven at various speeds by a portable steam engine, the thrust being measured by a dynamometer, while indicator diagrams showed the power developed by the engine. The construction of the propellers was peculiar in that, although there were four blades, these were arranged in pairs, parallel to each other, but separated by about three feet in order to permit of a lattice framing to be used, and thus obtain the necessary stiffness. In general appearance the construction resembles the Mangin screw propeller, and the framework being made of steel tubing, with a covering of canvas, both stiffness and lightness were secured.

The general arrangement of the apparatus was such as to give ample room for the proper circulation of the air, and the apparatus was carefully calibrated, in order that all possible errors might be corrected or eliminated. Each propeller was tested at about 10 different speeds, varying from 20 to 60 revolutions per minute, and the results were tabulated by plotting the experimental thrust and drawing curves through the points thus obtained. In this way it was thought that irregularities due to unavoidable errors of experiment would be corrected, and a fair average series of values obtained.

Taking the experiments as a whole, and making allowances for experimental errors, the following relations were verified:

1. The thrust varies as the square of the revolutions.

2. The horse power varies as the cube of the revolutions.

3. The thrust per horse power varies inversely as the revolutions.

"In the design of suitable lifting propellers for aeronautical purposes there are many practical and theoretical points to be considered. For instance, it would not be economical to arrange for too high a thrust per horse power, due to consideration of the weight of the propellers. Taking into account the weight of the propeller, there is a particular thrust per horse power which will give the highest efficiency." By use of the data derived from these experiments propellers of other sizes, and even somewhat different design, may be proportioned, and the thrust and horse power be approximately arrived at for any particular speed.

The resistance of the propellers may be divided into two kinds, that due to the skin friction of the surface, and that due to the framework structure of the propeller. The skin friction can be reduced by diminishing the width of the blades, the loss being nearly halved by making the blades one-half the width, and this also reduces the resistance due to the framework. The resistance of the structure is mainly due to the portion near the tips, where the velocity is greatest, the presence of struts in the central part absorbing comparatively little power. It is therefore desirable to make the structure as light as possible at the tips, where wire may be used to advantage for strengthening the frame. The surface friction can also be reduced by making the material of the blades as smooth as possible.

While it is by no means certain that the use of lifting propellers is the best method of attacking the problem of aerial navigation, yet it is very probable that in one form or another they will be important adjuncts, and the experimental data thus determined by Mr. Walker's experiments form an important contribution to the limited stock of information upon the subject.

REVIEW OF THE CONTINENTAL PRESS

The Railways of Africa.

THE present interest which attaches to everything relating to the development of Africa renders the article by Herr H. Claus upon the railways of Africa, appearing in a recent issue of *Glaser's Annalen,* especially timely, and a rather full abstract is therefore permissible.

Herr Claus first discusses the political condition of Africa, showing that apart from the three small republics of the Transvaal, the Orange Free State, and Liberia, and the two native states of Morocco and Abyssinia, the whole of the continent, with its 11,584.000 square miles area and 140,000,000 inhabitants, is under the rule of various European nations. It is estimated that seven-eighths of the area and nine-tenths of the population have come under European control, the greater portion of this being governed by England. Broadly, the British portion includes the Nile valley, the territory from the Cape to Lake Tanganyika, the island of Zanzibar, and the sources of the Niger; an area of nearly 3,700,000 square miles, with a population of 58,000,000. The portion controlled by France includes Algiers and Tunis, the country about Lake Tchad, the fertile Congo basin to the upper portion of the White Nile, also the territory between Abyssinia and Bab-El-Mandeb, and the Island of Madagascar; a total of nearly 3,000,000 square miles, and a population of 27,000,000.

The third in point of magnitude includes the territory controlled by the King of the Belgians, the Congo State, 865,000 square miles area and a population of 25,000,000; followed by the German possessions, which are in three groups, Togo and the Cameroons in the West, the large area between the mouth of the Kunena and the Orange river in the Southwest, and in the East the territory from the Indian Ocean to the great lakes; the whole number being about 861,000 square miles area, with 6,000,000 population. The Portuguese possessions include Delagoa Bay, the Mozambique coast, and the lower valley of the Zambezi, on the East, and on the West the province of Angola, the area being 849,000 square miles, and the population about 4,500,000. Italy possesses the territory of Massowah, on the coast of the Red Sea, with an area of 400,000 square miles, and a population of 2,000,000, and Spain controls a similar territory of the Atlantic coast south of Morocco, with an area of 212,000 square miles and 500,000 inhabitants.

The development of railways in all these territories has thus far been small, but many projects have recently been made public and a considerable portion of the work executed.

Starting from the French colonies of Algiers and Tunis in the north west, and following around the coast we find short spurs of railway extending into the interior, this being the most natural way of opening up the interior of such a continent. In Algiers and Tunis there were, at the close of 1897, 2,475 miles of railway, of which 2,150 miles were in Algiers and 325 miles in Tunis, in which latter colony 560 miles were also under construction. In Senegal there is a coast line from St. Louis to Dakar, a distance of 164 miles, and in the French Soudan the line from Kayes to Tulimandio, a distance of 335 miles, connects the upper navigable waters of the Senegal with those of the Niger, this connection greatly strengthening French power and influence in the western Soudan. A number of projected roads from points on the Guinea coast to interior towns are among the plans for the development of this portion of the coast, while the great project of a Trans-Saharan railway, extending from Algiers and Tunis down to Lake Tchad and to the navigable waters of the Niger, is well-known.

The Congo is navigable as far as Matadi, above which point the rapids known as the Livingstone Falls prevent navigation for a distance of 186 miles. Above these the Congo and its tributaries form a network of navigable streams of more than 9,000 miles in total length. The Congo

Railway Company has constructed a railway extending 236 miles from Matadi to Dolo, on Stanley Pool, this road, which was opened in July, 1898, taking the place of a difficult path by the falls, the journey over which formerly occupied 20 to 30 days. Plans for other railways in the Congo State have been discussed, but these have not yet taken definite shape.

In the Portuguese colony of Angola there has been under construction since 1888 a railway extending from Sao Paolo de Loando, on the coast, to Kasange, on the Kwango, a tributary of the Congo; nearly 200 miles of this road being now in operation, and other railways are projected in this colony. There has also been some discussion about a railway connecting the colony of Angola with the Portuguese possessions at Mozambique, on the east coast, but such a road would necessarily pass through the British territory of Rhodesia. Since the work is practically in the control of British capital and the construction undertaken by British labour, this point offers no insuperable difficulty, and the line now under construction from Mossamedes to Huilla is to be prolonged through Rhodesia and connected with the completed railway from Beira to Salisbury. It is also reported that an agreement has been made between England and Portugal for the construction of a harbour at the mouth of the Kunene, and the building of a railway from thence eastward to Buluwayo. In German southwest Africa a railway is being constructed by the German government to extend from the mouth of the river Swakop to Windhock, and 60 miles of this road have been in operation since April, 1898.

The most important portion of the railways of Africa, however, are those in the British Cape Colony, the Orange Free State, and the Transvaal Republic. These have a total length of 4,350 miles, the main western line extending from Cape Town to Buluwayo, and beyond to Salisbury, where it connects with the Portuguese line from Beira. Branch lines also connect with Port Elizabeth, Port Alfred, and Port Natal. Johannesburg and Pretoria are connected with the Indian Ocean by two railways, one running to the Portuguese harbor of Lourenzo Marquez, and the other to the port of Durban, in the British colony of Natal.

It is connection with the Egyptian railway up the Nile valley from Alexandria to Cairo, and beyond to Khartoum, that the proposed Cape-to-Cairo route has been considered, the whole being intended to form a mixed rail and water route through the whole length of the continent. A full discussion of this project is given in another place in this issue, and hence only a brief reference to it is here necessary. Herr Claus gives a detailed tabular statement of the length of the various portions of the route, his map showing very clearly the completed and proposed portions.

In British East Africa, an important piece of railway is being constructed from Mombassa to Port Victoria, on the Victoria Nyanza, this road being more than 600 miles long, passing over an elevation of more than 8,500 feet, north of Mount Kilimandjaro, and when completed it will enable direct communication to be made from the 25,000 square miles of area of the Victoria Nyanza to the sea.

At the beginning of 1899, 125 miles of this road were in operation.

Herr Claus discusses briefly a number of minor projects for railways from points on the coast into the interior, all of which are of interest in connection with the general opening up of the continent, but for further information respecting these reference must be had to his excellent map and article.

The Electrical Operation of Lock Gates.

SINCE 1896 there have been under construction at Ymuiden, in Holland, at the mouth of the Nordzee Canal, several new locks, which, with the mechanism for operating the gates, form the subject of an interesting paper in the Transactions of the Royal Institute of Engineers of the Netherlands, published also in the *Zeitschr. des Oesterr. Ingenieur und Architekten Vereines.*

The new basin, now completed, is 220 metres long, 10 metres deep, and 25 metres wide, and is connected with the outlet by a canal divided into two sections, forming auxiliary basins of 240 and 70 metres long respectively. This involves three sets of lock gates, the middle set acting as a re-

serve in case of accident, and each set consists of four gates, two for the flood and two for the ebb tide, thus making 12 gates in all.

The gates are made of steel, with double walls, so arranged that water may be admitted to provide the proper ballast, the weight being from 120 to 140 tons, and as these require to be opened and closed promptly and to be at all times under perfect control, the question of operative power had to be considered. In order to decide the selection of motive power a competition was arranged, the result of which was the submission of 13 designs, of which 1 was pneumatic, 8 hydraulic, and 4 electric. None of these appeared to be exactly satisfactory, but 2 electric and 2 hydraulic designs were purchased, and applied experimentally upon smaller gates, in order to furnish experience for the larger installations. As a result, an improved electrical design was made and has now been put into satisfactory operation.

One feature which rendered the use of electric power desirable was the distance separating the several sets of gates. This would have involved the use of long systems of high-pressure hydraulic piping, or three separate pumping plants, while in the case of electricity the current can readily be transmitted to all points. An electric plant is also necessary for lighting purposes, so that the whole power plant can be concentrated and operated to the best advantage. There were certain disadvantages in regard to electricity, as well. The rapid motion of the motors had to be converted into a slow, steady movement suitable for controlling such heavy masses; also the switching devices, especially in connection with automatic operation, became somewhat complicated; and the great enemy of electricity, dampness, was everywhere present.

Each gate is operated by means of a long connecting rod, attached at about the middle of the width, the inner end of the rod being connected to a traveling carriage to which motion is given by four endless chains passing over sets of sheaves. The chain-sheaves are operated by a train of gearing driven by the electric motor, the speed being reduced by a worm-wheel and pair of worms. In order to avoid shocks, strong springs are interposed at the connections of the chains with the carriage, and a friction connection is included in the gear train, which permits slipping if the stresses exceed a predetermined limit.

The motor in each case is placed in a separate chamber from the rest of the mechanism, this room being carefully cemented to prevent the access of moisture, the motor shaft passing through a fitted bearing in the wall, and there being three doors in the passage communicating with the chamber containing the operating gearing.

There is one 45-horse-power motor for each gate, and it is required that this shall open the gate in 1.5 minutes, against a difference of level of 10 centimetres, the motion being automatically arrested at each end of the travel. In addition to the mechanism for operating the main gates, the by-pass gates by which the lock chambers are filled and emptied are operated electrically, the whole being under the control of a single operator. The whole arrangement, including the connections, electric brakes, and wiring, appears to be remarkably well adapted to the peculiar conditions of the service, and it is probable that this installation will lead to the application of electric power to canal and reservoir locks elsewhere. The power station for the plant contains two steam-engines and dynamos of 100 h.p. each, besides a large storage battery.

The Progress of Electrochemistry in 1899.

THE constant growth in the industrial applications of electrochemistry and its importance as a commercial branch of electro-technics renders the review by Dr. M. Krüger of the progress made during 1899, a subject well worthy of review and notice, and from his paper in the *Elektrochemische Zeitschrift* some of the salient features are here abstracted.

An account of the various theoretical investigations which have been carried on during the year is included in the paper, but only those studies having a direct practical bearing are appropriate to these pages. Among these may be noted the work of Gross upon the relation between the electromotive force and chemical heat generated in galvanic elements, according

to the theory of Helmholtz, and the studies of Platner upon the dissociation theory. The studies of Foerster upon the electrolytic production of chlorates have also been valuable contributions to an important practical department of work.

In the department of the generation of electricity there has been a continuance of the efforts to make a more economical primary battery, and the battery of Wischnegorsky, consisting of cobalt and tin in a solution of bichromate of potash acidulated with sulphuric acid, and the element of Exner and Paulsen, using zinc and superoxide of lead in a mixture of dilute sulphuric and oxalic acids with gelatine, are the latest contributions to the list.

There has naturally been more attention directed to accumulators than to primary batteries, most of the efforts having been toward the improvement in details rather than in any radical change. The improved plate of Borntrager may be mentioned, this consisting of spongy lead formed under heavy pressure into a cellular shape, the edges and cross strips being subjected to a pressure of 100 atmospheres, while the intermediate portions receive only 5 to 10 atmospheres pressure. The investigations of Cahen and Donaldson as to whether it is better to charge a battery under constant current or constant pressure, have shown that with constant pressure the charging is effected in a shorter time and the discharge takes place at more uniform pressure, but that the efficiency is higher when the battery is charged with constant current.

The department of electro-metallurgy and galvanotechnics naturally forms the most important branch of electrochemistry, especially from the standpoint of the engineer, and in these lines of work material progress has been made during the past year. There has been but little noteworthy accomplished in the line of wet electro-metallurgical processes. The method of Cowper-Coles for obtaining zinc from sulphide ores consists in conversion into sulphates and oxides by roasting, followed by leaching with very dilute sulphuric acid, the zinc and copper going into solution. The metals are then separated by electrolysis, using anodes of lead, and disk shaped cathodes of iron.

In galvanotechnics a number of interesting processes have been developed. According to the experiments of Foerster, tough copper is deposited electrically if a 20 per cent. acid sulphate of copper solution is used, a temperature of 40° being maintained and a current-density of 1 ampere employed. Improvements have also been made in baths for brass and nickel plating. Lanseigne and Leblanc have shown that adherent deposits of silver, gold or copper may be made upon aluminum by adding phosphate of soda to the cyanide solutions of the respective metals. Electroplating upon wood has been accomplished by the method of Burgess, in which a conducting surface is obtained by treatment with sulphate of copper and sulphuretted hydrogen, and the electrical reduction of the resulting sulphide of copper.

The reverse process to electroplating, *i. e.*, the electrical removal of metallic coatings, is sometimes desirable. The method of Röder for removing nickel or copper plating from iron consists in the use of a solution of nitrate of soda, the plated iron forming the anode. With the passage of the current the nickel or copper goes into solution while the iron is not attacked, the dissolved metal being also thrown down at the negative pole as hydroxide. The pressure should not exceed 2 volts. The method of Linde is similar, using a solution of carbonate of ammonia, and is available for removing copper, cobalt, nickel, tin, or zinc from iron.

The above outline includes only the salient features of Dr. Krüger's paper, but will serve to give a general idea of the lines along which progress in electrochemistry is being developed, and with the growing appreciation of the capabilities of this branch of technical industry wider applications will surely follow.

Work on the Simplon Tunnel.

OPERATIONS are being steadily conducted upon the Simplon tunnel, and from a report in the *Giornale dei Lavori Pubblici*, some idea of the progress made during the last quarter of 1899 is obtained.

At the beginning of the month of October the total length of main tunnel bored from the two headings was 9,653 feet, while by December 31, this had been increased to 12,700 feet, the auxiliary tunnel

being slightly shorter, or 11,400 feet. This shows a progress of 3,047 feet for the three months, or a little more than 1,000 feet per month. Since the total length of the tunnel is to be 64,735 feet, it will only be necessary to maintain this rate to have the undertaking completed within the 5½ years of the original estimate.

Usually the rate of work attained at the beginning cannot be maintained in a work of this kind, but by the ingenious use of the auxiliary tunnel as a means of ventilation and the removal of material, it is expected that difficulties from heat and from the handling of débris will not occur to the same extent as in previous Alpine tunnels.

As the work advances it is evident that experience is aiding in its progress. During the three months under consideration there were removed from the Swiss end of the tunnel 4,916 cubic metres of rock, with an expenditure of 19,947 kilogrammes of dynamite, while from the Italian end the quantity of rock taken out was 25,336 cubic metres, and the consumption of dynamite 5,109 kilogrammes. This gives 4.06 kilogrammes of dynamite per cubic metre of rock at one end, and 4.96 kilogrammes at the other, a consumption decidedly lower than during the previous quarter's work.

The auxiliary tunnel is being carried well along with the main perforation, there being 9 connecting galleries opened in the portion on the Brieg side of the mountain, and 6 on the Iselle side, work now going on in the seventh connection. The effectiveness of the ventilation in keeping down the temperature is shown by the fact that the maximum temperature at the head of the workings on the northern portion is 23.6° C. (74° F.), and on the southern heading 30° C. (86° F.).

Much depression was caused among all engaged upon the tunnel by the death of the engineer, Alfred Brandt, on November 25, of apoplexy. It is a matter of curious coincidence that Louis Favre, the engineer of the St. Gotthard tunnel, also died of apoplexy during the course of the construction of that great work, the plans of both men thus being continued by others, although fully conceived by the originators before the work was commenced. Herr Brandt had gained valuable experience in the early part of his career in connection with the work of Colonel Edward Locher, the constructor of the remarkable railway up Mount Pilatus, as well as the later work of the Stansstadt-Engelberg railway, and much of the effective work thus far accomplished at the Simplon Pass has been due to the special devices designed by Herr Brandt himself, as well as to his carefully conceived plans for the undertaking.

Compression in Steam Cylinders.

THE experiments of Professor Dwelshauvers-Dery, of the University of Liége, upon the effect of clearance and compression, made about two years ago, and reviewed in these columns at the time (January and September, 1898), attracted much attention and created much discussion among steam engineers both in Europe and America, mainly because they appeared to contradict the hitherto accepted conclusion that the injurious effects of clearance may be neutralised by a proper amount of compression. The original account of these very accurate and interesting experiments appeared in the *Revue de Mécanique*, in which also appeared some of the criticisms of those who did not agree with the conclusions of Professor Dwelshauvers, and now we have a later communication by the Professor, which is of especial interest.

Among all his critics Professor Dwelshauvers says that the only one who appears to have grasped the true meaning of his experiments was Chief Engineer B. F. Isherwood, U. S. N., himself a most thorough and painstaking investigator in the same field, and in a communication to Professor Dwelshauvers, published in the *Revue de Mécanique* in April, 1899, Mr. Isherwood gave his views upon the Liége experiments to the public. We now have a final paper from Professor Dwelshauvers, also in the *Revue de Mécanique*, relating the results of some later experiments made by him for the purpose of testing Mr. Isherwood's views, and it is refreshing to see how completely the Professor is willing to acknowledge his acceptance of the modification in his original theory which Mr. Isherwood's criticism developed.

It will be remembered that Professor Dwelshauvers maintained that his experiments proved that increased compression

showed a positive loss, increasing rapidly as the degree of compression was increased, and he explained this action by stating that the compressed exhaust steam was subjected to cylinder condensation in a manner similar to that known to occur with live steam when first admitted to the cylinder.

Mr. Isherwood, after a careful examination, declared the experiments of Professor Dwelshauvers to be very accurate, and accepted fully the reliability of his results, but gave them a different interpretation. His theory was that the loss revealed by the experiments was due, not to cylinder condensation so much as to the increase in negative work due to the compression, while the positive, or absolute work, to use the expression of Hirn, remained with little or no change; the steam consumption being almost exactly proportional to the absolute work. If this theory be correct, such experiments, made with the absolute work varying according to the degree of compression, in such a manner that the indicated work remains constant, should show the same consumption of steam, whatever the degree of compression.

It was to verify the theory thus enunciated by Mr. Isherwood, that Professor Dwelshauvers repeated the experiments under the conditions suggested in that theory, and in the early part of 1899 three series of trials were made, one without compression, one with 4-10 compression, and with 6-10 compression, each series consisting of 10 trials except the last, which was interrupted after three trials had been made, owing to an accident with the apparatus.

In these experiments every effort was made to have the conditions identical throughout, so far as speed, brake-load, boiler-pressure, and indicated power were concerned, and the slight variations which occurred in these respects were carefully observed and recorded. Professor Dwelshauvers gives the data of the tests in his paper, very fully tabulated, and the comparative results of all the details may there be found. It is sufficient to observe here that Mr. Isherwood's theory was fully borne out by the trials, the consumption of steam per indicated horse power per hour remaining the same whatever the degree of compression when the indicated work remained constant.

Thus, during the three sets of trials the average of the results were as follows:

Steam consumption per i.h.p. hour:
Without compression..11.116 kilogrammes
With 4-10 compression.11.127 kilogrammes
With 6-10 compression.11.273 kilogrammes

These are practically identical, the variation being altogether within the errors of observation, and the individual results of the separate tests show a corresponding uniformity.

Again, taking the ratio of the indicated work to the total quantity of heat expended, we have for the thermal efficiency in the three series:

Without compression.....8.42 per cent.
With 4-10 compression.....8.44 per cent.
With 6-10 compression.....8.37 per cent.

The greatest difference here varies less than 1 per cent. from the mean, and the theory of Mr. Isherwood is completely confirmed.

These additional experiments, taken in connection with those previously made public by Professor Dwelshauvers, constitute a most important contribution to the subject of the action of steam in the cylinder, and his very fully tabulated data and results of the tests, together with this final discussion upon the theory of Mr. Isherwood, form a very satisfactory record of a most important investigation.

The Budapest Acetylene Exposition.

LIGHTING by acetylene has now reached a stage where it commands expositions of its own, much as was the case with electricity in the earlier phases of its application to lighting, and the second of these expositions was held in the latter part of last year at Budapest. A general review of the exhibits there shown forms the subject of a paper by Herr Karl Neudeck, in the *Zeitschrift des Oesterr, Ingenieur und Architekten Vereines,* the author being the delegate of the society to the exhibition, and this report forms an excellent view of the present status of the subject at the present time.

The use of acetylene gas involves three distinct elements; the carbide, the generator, and the burners. Although the manufacture of carbide is impracticable as an

exhibit, owing to the fact that commercial reasons demand the employment of large installations, driven by water-power, yet the material itself is an important subject for discussion, especially as regards its purity, most of the impurities which require additions to the generator for their removal from the gas, having their origin in imperfections in the method or material in manufacture. The presence of phosphorus or sulphur in the raw materials causes the formation of phosphuretted or sulphuretted hydrogen in the generator, while ammonia and other objectionable compounds are produced if impure carbide is employed. Purifiers are therefore generally necessary, but these may be considered as forming a portion of the generating apparatus.

Generators may be divided into two classes, the object of both being to effect a controlled combination of carbide and water. In one class a small quantity of water is fed to a large quantity of carbide, and in the other a small quantity of carbide is added to a large quantity of water. The first method permits generators of simple design, but it has a number of operative drawbacks, such as the generation of much heat, the clogging of taps and pipes, the inability to check generation of gas promptly, or to effect complete decomposition of the carbide, yet a number of practical generators upon this system have been made and were exhibited at Budapest, but most of these were for small installations.

The second class, in which the carbide is fed into a comparatively large quantity of water, avoids any objectionable elevation of temperature, the gas being cooled by bubbling up through the water, and most of the ammonia and sulphuretted hydrogen being absorbed. The complete immersion also insures the total decomposition of the carbide, and the only practical difficulty experienced in this class is that of regulating automatically the feeding of the carbide.

Both classes of generators were represented at the exposition, as well as a variety of burners, and also a few motors intended to be operated by acetylene instead of ordinary coal gas.

These various exhibits are illustrated and described in detail in Herr Neudeck's report, which is too voluminous to be reviewed except in a general way. As already stated, the dropping of water upon the carbide, the earliest system employed, was used in but few of the smaller generators exhibited, but the modifications of it in which the water rising or falling comes into or out of contact with carbide in a cage or open holder, appeared in several instances, the mechanical simplicity of regulation possible by this method evidently appealing to the designers.

Of more interest are the generators based upon the principle of feeding the carbide directly into a comparatively large body of water, decomposing it immediately and completely into the full quantity of gas possible; and the machines of this type exhibited were numerous, and many of them ingenious. For small plants the carbide may be fed in by hand, a few lumps sufficing to deliver into a suitable holder enough acetylene to supply several burners for an evening; but for regular service, such as in hotels, warehouses, and simlar situations some automatic feed is desirable. This automatic feed is generally accomplished by the rise and fall of the gas holder, some form of ratchet mechanism acting to drop a charge of carbide into the generator when the bell of the holder has reached its lowest position. Attempts to feed the carbide in through a funnel and feed-wheel have not been generally successful, there being a tendency to clog unless the carbide is crushed, and in the later machines the plan of having the carbide placed in a number of compartments, successively opened as the demands for it require, seems to be the favorite, most of the machines exhibited being of this type.

In the important department of burners there does not seem to have been much progress made, most of the exhibits being of the form employing two jets, impinging upon each other to form a flat flame at sufficient distance from the aperture to prevent the clogging due to overheating, so objectionable in the early forms of burners. The tips of the burners are still generally made of steatite, and in some cases shields are used to protect the capillary openings from the obstructing deposit which forms from the polymerization of the acetylene by heat. Burners of the Bunsen type, in

which air is mingled with the acetylene just before combustion, seem to have dropped out altogether, as none was exhibited, and the important field of mixed acetylene and oil gas, so successfully used in Germany for car lighting, was not shown, although this is the one application of acetylene which appears to have been established upon a commercial basis.

Reference has been made to the purification of acetylene, and among the methods employed at the exposition may be mentioned that of Wolff, using chloride of lime, and those of Frank and of Ullman; the former using an acid solution of copper salts, and the latter chromic acid.

Judging from the results of the use of acetylene in motors at the exposition, it is still too expensive to be employed as a source of motive power. The engine tested used 500 to 700 litres of illuminating gas per horse-power-hour, and 180 to 220 litres of acetylene, but the higher cost of the latter brought the cost of a h. p. hour up to 3.5 to 4.9 kreutzers for gas, and 15 to 18 kreutzers for acetylene, although the latter might occasionally find employment when a greater power was desired in a given space and weight, regardless of cost.

The Technical Applications of Liquid Air.

EVER since the development of practical processes for the commercial production of liquefied air the question has been asked: "Of what practical use is it?" Various answers have been given, some preposterous, others unwarranted, and still others more moderate and reasonable. To this latter class belong the paper by Dr. Carl Linde, presented before the German Society of Naturalists and Physicians, and published in a recent issue of the *Zeitschrift des Vereines deutscher Ingenieure.*

Dr. Linde points out that liquid air possesses three properties which may be considered in connection with its possible technical applications: its low temperature, its adaptability for the conversion of calorific energy into mechanical work, and the possibility of using it to separate the constituents, nitrogen and oxygen, by fractional distillation.

The applications of liquid air as a refrigerant are shown by Dr. Linde to be very limited. He demonstrates that a given amount of cooling will cost theoretically 17 times as much when performed with liquid air, as when an ordinary refrigerating machine is used, and that owing to the much lower efficiency of the liquefying apparatus, the actual cost is about 40 times greater for the former than for the latter apparatus. Liquid air is therefore only applicable when much lower temperatures than those possible with refrigerating machines are demanded, or in the limited number of cases. such as in medicine and surgery, in which cost is of secondary consideration.

A similar state of affairs exists with regard to the use of liquid air as a source of motive power. It is true that liquid air can be used to operate motors, but even if it were to be had without cost the efficiency is very much lower than is the case with motors operated with liquid hydrogen oxide (*i. e.*, water). We have also seen that the cost of liquefying the air is also high, so its use for motive power is probably to be limited to such special applications as torpedoes, submarine boats, and other similar work. An indirect use of liquid air, however, is that in connection with petroleum in internal combustion motors. In this case the charge of liquid air is mixed with the proper proportion of petroleum, and the power developed by the complete combustion utilized in a cylinder. A powerful motor of small weight may thus be constructed, possibly well adapted for motor vehicles. The application of liquid air as an explosive is also mentioned, although experience with it on the Simplon tunnel work has not been favorable.

The fractional evaporation of liquid air, possible because of the difference in the boiling points of liquid oxygen and nitrogen, may prove of commercial value for the production of air containing a large excess of oxygen. When liquid air is permitted to evaporate slowly at atmospheric pressure the vapour which comes off at first consists of 92 per cent. nitrogen and 8 per cent. oxygen, the last remaining portion being rich in oxygen. By using the cold produced by the evaporation of the first portion to assist in the liquefaction of a new portion of air there need be little or no waste, and as a result it is possible to produce air containing 50 per cent. of oxygen for 2.5 pfennigs per cubic metre.

REVIEW OF THE AMERICAN PRESS

Electric Traction Under Steam Conditions.

NOTWITHSTANDING the success which has attended the application of electric traction to street and suburban service there appears to be a marked hesitancy of the main line railways to consider its use in general work. The most extensive installations which have been made of electric traction upon roads formerly operated entirely by steam have been those of certain branches of the New York, New Haven and Hartford Railroad system, about the city of Hartford, in Connecticut. The paper of Mr. Edward C. Boynton, who is actively connected with the management of these electric railways, therefore attracted much interested attention when presented recently before the American Institute of Electrical Engineers, and a full review of it is here given.

In considering electric traction under steam railway conditions Mr. Boynton divides the local passenger traffic to which it is applicable into two classes. One of these is suburban traffic, now largely carried on by trolley cars, and the other is that existing between cities and towns in close proximity. The first kind of service can only be improved by the use of higher speeds, and unless this gain can be made there is little advantage in introducing the electrically-operated railway. In densely populated districts, however, where there are numerous towns within moderate distances, the present steam communications, effected by means of heavy trains at intervals of several hours, may advantageously be replaced by an electric train service, consisting of two or three-car trains, running every half-hour from each end, with a maximum speed of fifty to sixty miles per hour, and a fare of one cent per mile. Such conditions exist on steam railroads in many parts of the United States. It is on such branch lines, or such short direct lines between cities large enough to provide a constant travel in both directions, that electric traction may be successfully introduced, and it is this kind of service that the roads upon which Mr. Boynton gained his experience are furnishing.

It does not appear probable that electricity will supersede the steam locomotive for hauling freight, at least not until conditions have very materially changed. The economy of the modern freight locomotive and its satisfactory operation in practical service render this branch of railroading one which is least likely to be replaced by any change in motive power. The same is true of through express trains on trunk lines, so that the introduction of electricity on main line work must be expected to come by way of the branch lines, as above indicated, at least at first.

Mr. Boynton gives some interesting data about equipment and operation, especially in connection with the all-important question of costs. During the experimental period reliable data were lacking, and very indefinite answers only could be given to most necessary questions. Several methods may be adopted in the equipment of a road for operation by electricity. These methods are:

First: The purchase of electric locomotives of sufficient power and weight to haul its standard passenger coaches.

Second: The equipment of a number of its standard coaches as motor cars.

Third: The purchase or building of a sufficient number of special light passenger coaches, some of which are equipped as motor cars, and the withdrawal of its standard coaches entirely from this service.

Fourth: Shall freight be hauled by electricity or steam?

The use of electric locomotives is recommended only when the travel is heavy enough to require trains of four or more cars and the runs are long. It has the advantages of providing a form of motive power similar to the steam locomotive, rendering little or no change necessary in the making up or dispatching of trains, and hence is apt to be regarded with favor by railway managers.

The second method, that of equipping

standard coaches as motor cars, must be regarded as the cheapest and most convenient way to make the change from steam to electricity. Mr. Boynton goes at length into the details of equipping coaches in this manner, describing the construction of the motor truck suitable for the conversion, together with methods of wiring and other features.

The third method is very similar to the second, except that the use of light trailers, especially built for the service, enables the dead weight to be reduced, thus reducing the weight of permanent way, and diminishing other details.

The question of hauling freight by electricity Mr. Boynton considers as aside from his discussion of the subject, regarding it as a matter which concerns the future more than the present.

In addition to the cost of equipping the motor cars, the construction and equipment of the power house must be considered. Without going into the details of the engineering construction, and emphasizing only the necessity for selecting a location where water is plentiful and fuel cheap, he states that experience has shown the cost of a power station to be from $80 to $90 per kilowatt, exclusive of the cost of the land.

The cost of operation necessarily varies in different localities, especially for the steam locomotive, so that comparisons cannot readily be made. Mr. Boynton assumes, however, a fair average cost of running a steam locomotive, with coal at $2.30 per ton, and including water, wages, repairs, etc., to be 22 cents per mile, or including wages of train crew, 30 cents per mile. For the electric traction the corresponding costs, based upon his own extensive experience, foot up but 14 cents per train-mile.

The Testing of Steam Engines.

A REVIEW of a portion of a forthcoming work by Mr. George H. Barrus, on the testing of steam engines, is given in a recent issue of the *Engineering Record*, and in view of Mr. Barrus' extended experience in this special branch of engineering some of the points will bear repetition and emphasis.

Mr. Barrus gives some valuable suggestions with regard to the measurement of feed water, and although this relates more to boiler than engine testing, yet it is important in both cases, and sometimes in engine testing large quantities of water other than feed must be measured. Naturally the best method of determining a quantity of water is the indirect one of weighing it, but this is not always practicable. Meters, when used, should be carefully calibrated, this being best done by running a large volume of water through the meter, the water being delivered alternately into two barrels, the count of barrels being kept and the weight of water in a barrel determined. A rating can thus be obtained by which the meter readings can be corrected.

The orifice method of measuring water may be adopted when any change in existing connections is not permissible. If the head of water on a given orifice is maintained constant, and the flow accurately timed, the rate of flow can be determined afterwards, and the amount of water computed. The importance of testing for leaks is emphasized, and a leakage trial should be made immediately after a test, care being taken to have boiler pressures and all conditions which might affect leakage kept as nearly the same as possible as they were during the trial.

Mr. Barrus naturally gives careful attention to the use of the indicator, and, assuming that the reader is familiar with the general use of the instrument, he goes on to give many useful hints derived from long experience with it in engine testing. The best methods of giving correct motion to the paper drum for engines of different kinds, the arrangement of cords for simultanous use of several instruments on multiple-cylinder engines, and the avoidance of error by the use of the best methods of piping, all these are discussed, and the use of the judgment encouraged in selecting the method of connection best adapted to the case under test.

For those who admire a single line, clean-cut diagram, the method of Mr. Barrus for getting at the true performance may be interesting, he evidently preferring to obtain a knowledge of the actual work of the steam rather than to get a show card.

"In taking diagrams from an engine

with the object of determining its power, it is not desirable to limit the diagram to a single revolution. The marking point of the indicator should be applied long enough to obtain four or five diagrams, corresponding to that number of successive revolutions, in order that the effect which the fluctuations in the governing mechanism has upon the diagrams may be provided for.

"When a load is extremely fluctuating this system should be carried still further. The period of taking the diagram should extend over at least a full minute, though it is unnecessary to make it a continuous diagram for this length of time. The marking point can be preferably applied for three or four revolutions at the beginning of, say every ten seconds of a minute, and in that way the record applies to some twenty revolutions spread over the full period. Having these diagrams now on the same card, an average line can be dotted in by hand, using the best judgment after examining the appearance of the various diagrams and their location."

This method is especially applicable in testing engines in electric-railway power-plants, and indeed except by some system of this kind it is not practicable to obtain a fair idea of the actual indicated horse-power. By taking diagrams at intervals of not more than ten or fifteen minutes, all engines being indicated simultaneously at a given signal, a general record of the total power may be worked up which will be very near the actual condition of affairs. It is in such details that the judgment and experience of the engineer appears, and it is only by such intelligent use of instruments and methods that tests of permanent value can be made.

Modern Masonry Construction.

THE paper of Mr. David Molitor upon the present status of engineering knowledge respecting masonry construction, presented before the Detroit Engineering Society, and published in the *Journal of Associated Engineering Societies*, forms a valuable contribution to one of the oldest branches of engineering work.

After showing that, in spite of the voluminous mass of literature upon the subject, the knowledge of the theory is really very meagre, Mr. Molitor proceeds to take up various branches, briefly indicating the most modern ideas as compared with the time-honored formulas and methods of the text books.

Beginning with the question of earth pressure, the earlier theories are examined, and it is shown that they are based on assumptions which cannot be harmonized with the facts observed in practice. The assumptions that earth possesses a constant angle of repose, that separation takes place by the severing and motion of definite prisms, and that there is a definite point of application of the resultant of earth pressure against a wall, these are all practically erroneous, as are consequently the theories built upon them. The French experiments of Leygue and of Chaudy have shown more clearly the true behavior of earth particles, and while further experiments on a large scale are desired, yet it is possible to analyze graphically the conditions in a manner which enables retaining walls to be constructed in a rational manner. Rupture is shown to take place along a curve, not on a plane; the question of the friction of the particles must be considered, and the point of application of the resultant of the pressure must be determined for each case.

The important subject of masonry arches is examined at length, and the weight which the Austrian experiments have had upon the revision of the older theories is acknowledged. The application of the graphical and analytical methods to fixed arches is shown by practical examples, although it is maintained at the same time that the large factor of uncertainty necessitates a very high factor of safety in such structures. Hinged arches are advocated as decidedly preferable, both as being free from initial stresses otherwise present in fixed arches after releasing false work, and because small abutment displacements and changes in temperature do not affect the magnitude or distribution of stress in the arch ring.

Mr. Molitor gives some attention to reinforced concrete masonry construction, both as applied to retaining walls and to arches, the methods of Melan, Moeller, and Monier being especially discussed, and the combination recommended. The introduc-

tion of iron or steel in concrete at once permits tensile stresses to be incurred, a large economy thus being made possible.

"The widely different physical properties of concrete and iron do not seem to offer any serious obstacles, as was at first predicted; at least, none have developed during past experience. Concrete appears to possess an adhesive strength with iron which is equal to or even greater than the tensile strength of the former; the coefficients of expansion are nearly enough equal in the two materials to offer no serious objections, and by a proper distribution of loads their elastic properties may be harmonized as to make them work fairly well together."

Mr. Molitor's paper emphasizes the importance of providing by experiment a greater fund of reliable data upon which to base correct theories, and urges the initiation of full sized tests of retaining walls under various earth pressures on a scale comparable with the Austrian arch experiments, and shows the futility of deducing, or attempting to deduce, the conditions in a great masonry structure by miniature experiments in the laboratory.

Annealing by Electricity.

THE use of hardened steel in various constructions, notably in armor plate and in the construction of burglar-proof vaults, brings into notice the difficulty of drilling or otherwise working the material by machine tools after the hardening process has been performed. An interesting paper upon the method of removing the hardening locally, by means of the process of electric annealing, was recently presented before the Engineers' Club of Philadelphia by Mr. Charles A. Dougherty, and published in the *Proceedings* of the Club.

Harveyized nickel-steel armor plate, or plates prepared by the Krupp process, are altogether too hard to be drilled or worked after hardening, and hence it has been the practice either to drill all holes before hardening, or to protect the surface of the plates in patches or strips to prevent carburation wherever holes were expected to be drilled. It is very often difficult to determine the exact location of the holes required, and even with the utmost care in the preparation of the drawings it is found necessary to proceed with the fitting of the plates on the vessel before the holes can all be precisely placed.

Attempts have been made to anneal spots where holes were to be drilled, but neither the oxy-hydrogen blowpipe nor the electric arc proved satisfactory. Under these circumstances experiments have been made with an electric apparatus similar to that employed for electric welding, with results which appear to be satisfactory and which are described in detail in Mr. Dougherty's paper. The apparatus, as made by the Thomson Electric Welding Company, consists of an alternating current generator giving a voltage of 300, and an amperage of 100. The annealing machine proper is an alternating-current transformer similar to the well-known transformers used in welding steel rails.

"The transformer is of the copper-clad type; that is, one in which the secondary is composed of two copper castings, each having a rectangular groove; when bolted together these form a closed rectangular frame in which the primary coil is held. The hollow space intervening between the primary and secondary is filled with a heavy body oil called "transil" oil. This oil acts both as an insulator and a conductor of heat from primary to secondary. The secondary, by completely surrounding the primary, affords an excellent mechanical protection, and prevents electrical as well as magnetic leakage. The latter features are quite important, since it is necessary to operate the annealer on board vessels in exposed positions during construction, yet it may be handled with immunity from electric shocks, even when operated in rain or in heavy snow. The primary coil of this transformer consists of a copper ribbon, each turn of the coil being insulated from the next by thin asbestos paper. The ratio of conversion is 100 to 1, and when the maximum voltage of 300 is generated at the brushes of the generator, there is about 2.5 to 2.8 volts at the terminals of the secondary of the transformer."

This transformer is connected to two copper terminals, forming contacts by means of which the current is made to enter and leave the plate to be annealed. These contacts are provided with an internal water circulation to keep them cool,

and are made of various forms, according to the work to be done.

The passage of the current raises the temperature of the spot to about 1,000° F., with the result of withdrawing the temper very completely. The contact surface on the plate is seldom more than about half an inch square; yet 10,000 amperes are made to flow through it during the process of annealing. This current density per contact area is equivalent to 40,000 amperes per square inch, a density which is only rendered possible by the thorough cooling of the copper contacts by the continuous water-circulation through them.

It was at first supposed that the heating would draw the temper of the hardened steel without any especial method of cooling afterwards, but experience proved that when the current was shut off the heat was carried away so rapidly by the surrounding mass of metal that the heated spot became chilled, just as if it had been plunged into cold water. As a consequence of this action it was found that only a gradual and slow withdrawal of the current would produce the complete effect of annealing.

The practical operation of this apparatus at Cramps' shipyard in Philadelphia, has shown that the temper can be drawn at any desired spot so that a hole can be drilled, while at the same time the resisting power of the rest of the plate remains unchanged. Even with the new Krupp process armor, in which the surface hardening extends to a depth of two inches, the electric annealing is perfectly accomplished.

An American Drafting Room.

FORMERLY it was thought that any out-of-the-way room would serve for the draftsmen of a machine shop, and some proprietors seemed to grudge every dollar which was expended in making drawings, or working over designs. A marked contrast to this state of affairs is seen in the new drafting rooms of the Brown & Sharpe Manufacturing Company, of which an excellent account is given in a recent issue of the *American Machinist*.

In connection with the offices for the engineers, the drafting room occupies an entire floor 127 feet long by 47 feet wide, besides additional space for photographing and blue printing departments. About one-third of the floor is divided off for private engineering offices, and the balance is equipped with drafting tables, cases for drawings and general drafting appliances. A saw-tooth skylight furnishes ample light, the lighting being controlled by shades and diffused by the color of the walls, while especial attention has been given to the warming and ventilation; the theory being held that the physical comfort of the men is essential to the production of satisfactory results.

It is necessary to examine the photographs of the room to obtain a proper idea of the arrangement, but some features of the system may be referred to here. All drawings are filed in cases in the room where they are readily accessible, and a card index enables any sheet to be found at once, and the old-time experience of wasted time hunting for missing drawings is made an impossibility. Drawings and blue prints sent out into the works are charged to the department receiving them, and all changes in patterns, and shop notes suggesting changes, are recorded on the drawings themselves. Sketches and notes are filed and indexed, and the card index of photograph negatives includes prints of each negative, so that it may be identified by appearance as well as by name.

An 8 foot reversible blackboard is a convenience for use in making full size preliminary sketches to get general proportions, and the drawing tables are of two sizes, 3 by 8 feet and 3 by 16 feet, there being accommodation for fifty draftsmen without crowding.

The whole equipment is a model for imitation wherever a modern drafting room is under consideration, and there can be no doubt that the cheerful and attractive surroundings fully repay their cost in the higher character of service given by the men there occupied.

The Discharge of the Niagara River.

IN view of the increasing use which is being made of the Niagara hydraulic power the recent measurements of the flow of water in the Niagara, made under the direction of the U. S. Board of Engineers on Deep Waterways, is of more than usual interest. A very full account of this work is contained in a paper by Mr. Clinton W.

Stewart, recently presented before the Western Society of Engineers, and from the very elaborate account the following is condensed.

The measurements were made at Buffalo, at the head of the Niagara river, or the outlet of Lake Erie, the discharge section being taken on the line of the guard rail on the north side of the International Bridge about 3 miles below the head of the river. By thus using the bridge it was possible to take accurate soundings and readily obtain a correct cross section, two distinct and independent sets of soundings being taken, and the discrepancies gone over and corrected.

The cross section having thus been determined, the velocities at a number of points of the section were taken by the use of current meters of the Haskell form. This is a propeller meter of the so-called "Woltmann Mill" type, the modifications being in the form of the blades and in the introduction of electrical recording and controlling apparatus. A make-and-break device in the body of the meter causes electrical contact to be made and interrupted once for every revolution of the spindle. A stop watch is also included in the circuit and so arranged that the starting of the stop watch completes the circuit, or vice versa. The current meters were all carefully calibrated and the results of many trials plotted on section paper, any variations from the mean to any great extent being rejected, and the rest treated by the method of least squares. The care which was given to the rating of the meters renders the results very trustworthy, and it is probable that the instrumental errors in the final results are both few and unimportant.

The general method of proceeding in taking the discharge measurements was to measure the velocity at some percentage of the depth at stations on the cross section, passing from one to the other as rapidly as possible. These stations were called the meter stations and were about 80 feet apart. In the short spans of the bridge they were situated at the stations 2-8ths and 6-8ths, and in the longer spans at the stations 2-12ths, 6-12ths, and 10-12ths. In this way each observation represented a width of river corresponding to one-half or one-third of the span and was located in the middle of that part. As the general shape of the cross section of each span was somewhat triangular, in order to reduce the observed velocity to mean velocity it was necessary to have a system of vertical curves, showing the variation of the velocity in a vertical plane, and a system of transverse curves showing the variation of velocity as the river is crossed. The combination of the two sets of curves gives a coefficient which, multiplied by the area of the cross section of the corresponding one-half or one-third span gave the discharge.

The details of this portion of the work are given very fully in Mr. Stewart's paper, the coefficients being computed for every foot variation in the height of the water, within the limits of observed variations of level. Gauges were also set to enable the slope of the surface to be measured, and the effect of wind conditions was also carefully observed.

After a careful study of the 72 discharges which were measured, 43 were accepted as being the most reliable, these covering a range of level in the lake of about 2.3 feet. A curve was adjusted to fit these 43 observations by the method of least squares, this enabling discharges for any intermediate level to be taken off.

Taking the mean level of Lake Erie at 572.78 feet, this being the mean of the annual elevations of the lake at Cleveland from 1871 to 1895, the corresponding discharge of the Niagara river was found to be 229,100 cubic feet per second. This level, however, was found to be too high by 0.3 feet, from 10 years' observations of the difference in level between Cleveland and Buffalo, and making this correction the mean flow of the river is given as 221,500 cubic feet.

"Should a certain amount of the discharge of the lake be diverted from the natural outlet, the effect on the lake level can be directly obtained by taking the proportion of the amount diverted to the rate of increase or decrease in discharge per foot of rise of the lake. Should 10,000 cubic feet per second be diverted from the discharge of the Niagara river by the Chicago drainage canal, the effect would be to lower the level of Lake Erie by 0.4 feet."

THE ENGINEERING INDEX

INTRODUCTORY.

The object of this Index is to supply all persons interested in engineering and industrial pursuits with, first, an expert descriptive summary clearly indicating the character and purpose of the leading articles published currently in the established technical journals of the United States, Great Britain, and the Continent—in all languages; and, secondly, an inexpensive means of readily obtaining any portions of this literature that may be desired by our readers.

We hold ourselves ready to supply—usually by return of post—the full text of every article indexed, *in the original language;* and our charge in each case is regulated by the cost of a single copy of the journal in which the article is published. The price of each article is indicated by the letter following the number. When no letter appears, the price of the article is 20 cts. The letter A, B, or C denotes a price of 40 cts.; D, of 60 cts.; E, of 80 cts.; F, of $1.00; G, of $1.20; and H, of $1.60. In ordering, care should be taken to *give the number* of the article desired, not the title alone.

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THE PUBLICATIONS REGULARLY REVIEWED AND INDEXED.

The titles and addresses of the journals regularly reviewed are given here in full, but only abbreviated titles are used in the Index. In the list below, *w* indicates a weekly publication, *b-w*, a bi-weekly, *s-w*, a semi-weekly, *m*, a monthly, *b-m*, a bi-monthly, *qr*, a quarterly, *s-q* semi-quarterly, etc. Other abbreviations used in the Index are: Ill—Illustrated; W—Words; Anon—Anonymous.

American Architect. *w.* Boston, U. S. A.
American Electrician. *m.* New York.
Am. Engineer and R. R. Journal. *m.* New York.
American Gas Light Journal. *w.* New York.
American Geologist. *m.* Minneapolis, U. S. A.
American Jl. of Science. *m.* New Haven, U. S. A.
American Machinist. *w.* New York.
Am. Manufacturer and Iron World. *w.* Pittsburg, U. S. A.
American Shipbuilder. *w.* New York.
Annales des Pontes et Chaussées. *m.* Paris.
Architect. *w.* London.
Architectural Record. *q.* New York.
Architectural Review. *s-q.* Boston, U. S. A.
Architect's and Builder's Magazine. *m.* New York.
Australian Mining Standard. *w.* Sydney.
Automobile Magazine. *m.* New York.
Automotor & Horseless Vehicle Jl. *m.* London.
Bridges. *m.* Chicago.
Brick Builder. *m.* Boston, U. S. A.
British Architect. *w.* London.
Brit. Columbia Mining Rec. *m.* Victoria, B. C.
Builder. *w.* London.
Bulletin Am. Iron and Steel Asso. *w.* Philadelphia, U. S. A.
Bulletin de la Société d'Encouragement. *m.* Paris.
Bulletin of Dept. of Labor. *b-m.* Washington.
Bulletin of the Univ. of Wis., Madison, U. S. A.
Bull. Int. Railway Congress. *m.* Brussels.
California Architect. *m.* San Francisco, U. S. A.
Canadian Architect. *m.* Toronto.
Canadian Electrical News. *m.* Toronto.

Canadian Engineer. *m.* Montreal.
Canadian Mining Review. *m.* Ottawa.
Chem. Met. Soc. of S. Africa. *m.* Johannesburg.
Colliery Guardian. *w.* London.
Compressed Air. *m.* New York.
Comptes Rendus de l'Acad. des Sciences. *w.* Paris.
Consular Reports. *m.* Washington.
Contemporary Review. *m.* London.
Deutsche Bauzeitung. *b-w.* Berlin.
Domestic Engineering. *m.* Chicago.
Eclairage Electrique. *w.* Paris.
Electrical Engineer. *w.* London.
Electrical Engineering. *m.* Chicago.
Electrical Review. *w.* London.
Electrical Review. *w.* New York.
Electrical World and Engineer. *w.* New York.
Electrician. *w.* London.
Electricien. *w.* Paris.
Electricity. *w.* London.
Electricity. *w.* New York.
Elektrochemische Zeitschrift. *m.* Berlin.
Elektrotechnische Zeitschrift. *w.* Berlin.
Elettricita. *w.* Milan.
Engineer. *w.* London.
Engineer. *s-m.* Cleveland, U. S. A.
Engineers' Gazette. *m.* London.
Engineering. *w.* London.
Engineering and Mining Journal. *w.* New York.
Engineering Magazine. *m.* New York & London.
Engineering News. *w.* New York.
Engineering Record. *w.* New York.
Eng. Soc. of Western Penn'a. *m.* Pittsburg, U. S. A.
Fire and Water. *w.* New York.
Foundry. *m.* Detroit.
Gas Engineers' Mag. *m.* Birmingham.
Gas World. *w.* London.
Génie Civil. *w.* Paris.
Gesundheits-Ingenieur. *s-m.* München.
Giorn. Dei Lav. Pubb. e d. Str. Ferr. *w.* Rome.
Glaser's Ann. f. Gewerbe & Bauwesen. *s-m.* Berlin.
Heating and Ventilating. *m.* New York.
Horseless Age. *m.* New York.
Ice and Refrigeration. *m.* New York.
India Rubber World. *m.* New York.
Indian and Eastern Engineer. *m.* Calcutta.
Industries and Iron. *w.* London.
Inland Architect. *m.* Chicago.
Iron Age. *w.* New York.
Iron and Coal Trades Review. *w.* London.
Iron & Steel Trades Journal. *w.* London.
Iron Trade Review. *w.* Cleveland.
Journal Assn. Eng. Socities. *m.* Philadelphia, U. S. A.
Journal of Electricity. *m.* San Francisco.
Journal Franklin Institute. *m.* Philadelphia.
Journal of Gas Lighting. *w.* London.
Journal Royal Inst. of Brit. Arch. *s-qr.* London.
Journal of Sanitary Institute. *qr.* London.
Journal of the Society of Arts. *w.* London.
Journal of U. S. Artillery. *b-m.* Fort Monroe, U. S. A.
Journal Western Soc. of Eng. *b-m.* Chicago, U. S. A.
L'Energie Electrique. *w.* Paris.
Locomotive. *m.* Hartford, U. S. A.
Locomotive Engineering. *m.* New York.
Machinery. *m.* London.
Machinery. *m.* New York.
Marine Engineer. *m.* London.
Marine Engineering. *m.* New York.
Marine Review. *w.* Cleveland, U. S. A.
Master Steam Fitter. *m.* Chicago.
Mechanical World. *w.* London.
Mechanical Engineer. *w.* Manchester.
Mem. de la Soc. des Ing. Civils de France. *m.* Paris.
Metal Worker. *w.* New York.
Mines and Minerals. *m.* Scranton, U. S. A.
Mining and Sci. Press. *w.* San Francisco, U. S. A.
Mining Journal. *w.* London.
Mining Reporter. *w.* Denver, U. S. A.
Mitt. aus d Kgl. Tech. Versuchsanst. Berlin.
Mittheilungen des Vereines für die Förderung des Local und Strassenbahnwesens. *m.* Vienna.
Modern Machinery. *m.* Chicago.
Moniteur des Architects. *m.* Paris.
Moniteur Industriel. *w.* Paris.
Municipal Engineering. *m.* Indianapolis, U. S. A.
National Builder. *m.* Chicago.
Nature. *w.* London.
Nature. *w.* Paris.
Nautical Gazette. *w.* New York.
New Zealand Mines Record. *m.* Wellington.
Nineteenth Century. *m.* London.
Oest. Monatsschr. f. d. Oeff. Baudienst. *m.* Vienna.
Oest. Zeitschr. f. Berg- & Hüttenwesen. *w.* Vienna.
Ores and Metals. *w.* Denver, U. S. A.
Plumber and Decorator. *m.* London.
Popular Science Monthly. *m.* New York.
Power. *m.* New York.
Practical Engineer. *w.* London.
Pro. Am. Soc. Civil Engineers. *m.* New York.
Proceedings Engineers' Club. *qr.* Philadelphia, U. S. A.
Progressive Age. *s-m.* New York.
Railroad Car Journal. *m.* New York.
Railroad Gazette. *w.* New York.
Railway Age. *w.* Chicago.
Railway Magazine. *m.* New York.
Railway Master Mechanic. *m.* Chicago.
Railway & Engineering Review. *w.* Chicago.
Review of Reviews. *m.* London & New York.
Revue de Mécanique. *m.* Paris.
Revue Gen. des Chemins de Fer. *m.* Paris.
Revue Technique. *b-m.* Paris.
Revue Universelle des Mines. *m.* Liége.
Rivista Marittima. *m.* Rome.
Sanitary Plumber. *s-m.* New York.
Schweizerische Bauzeitung. *w.* Zürich.
Scientific American. *w.* New York.
Scientific Am. Supplement. *w.* New York.
Stahl und Eisen. *s-m.* Düsseldorf.
Stevens' Indicator. *qr.* Hoboken, U. S. A.
Stone. *m.* New York.
Street Railway Journal. *m.* New York.
Street Railway Review. *m.* Chicago.
Tramway & Railway World. *m.* London.
Trans. Am. Ins. Electrical Eng. *m.* New York.
Trans. Am. Ins. of Mining Eng. New York.
Trans. Am. Soc. of Civil Eng. *m.* New York.
Trans. Am. Soc. of Heat & Ven. Eng. New York.
Trans. Am. Soc. Mech. Engineers. New York.
Transport. *w.* London.
Western Electrician. *w.* Chicago.
Wiener Bauindustrie Zeitung. *w.* Vienna.
Zeitschr. d. Oest. Ing. u. Arch. Ver. *w.* Vienna.
Zeitschr. d. Ver. Deutscher Ing. *w.* Berlin.
Zeitschrift für Elektrochemie. *s-m.* Halle a. S.
Zeitschrift für Elektrotechnik. *s-m.* Halle a. S.

ARCHITECTURAL ENGINEERING

CONSTRUCTION.

Cast Iron.

See Mining and Metallurgy, Iron and Steel.

Chimney.

See Mechanical Engineering, Steam Engineering.

Columns.

The Design of Columns for Sheds Exposed to Wind and of Concrete Bases for Columns. Leopold Mensch. Computations for concrete bases, and calculations of structures like freight and passenger sheds. 900 w. Eng News—Feb. 1, 1900. No. 32354.

Concrete Floors.

Tests of a Reinforced Concrete Floor. Describes investigations made at a Montreal office building. 800 w. Eng Rec—Feb. 3, 1900. No. 32316.

Derrick.

See Electrical Engineering, Power.

Grand Stand.

A Large Steel Grand Stand. Illustrated description of a structure at Yonkers, N. Y., which is 400 ft. long, 62 ft. wide, and seats 7,700 spectators. The structural details of the column and roof connections, and other special features, are explained in detail. 1900 w. Eng Rec—Feb. 10, 1900. No. 32425.

Reconstruction.

Reconstruction of the Manhattan Bank Building. Illustrated description of the repairs and strengthening of an office building seriously damaged by fire. Describes the strengthening of the foundations, re-enforcement of columns, and construction of fireproof floors. 1000 w. Eng Rec—Feb. 3, 1900. No. 32315.

Underpinning.

Street-Front Reconstruction. Illustrated description of the method used in a Toronto building to replace masonry wall piers with steel columns on the same foundations. 500 w. Eng Rec—Feb. 10, 1900. No. 32426.

HEATING AND VENTILATION.

Blowing Fans.

Methods of Testing Blowing Fans. Review of a paper by R. C. Carpenter, explaining the sources of error in such tests and describing the apparatus and methods he has found most satisfactory. 2000 w. Eng Rec—Feb. 3, 1900. No. 32317.

Car Ventilation.

See Railway Affairs. Equipment.

Dust.

Removal of Dust from a Boiler Room. Illustrated review of a paper by A. A. Cary on a plant designed to intercept all the dust given off in the boiler house of a wire-insulating plant. 900 w. Eng Rec—Feb. 3, 1900. No. 32318.

Hospital Ventilation.

Neglect of Ventilation in Some Hospitals. Thomas Barwick. Read before the Am. Soc. of Heat. and Ven. Engs. Describes the conditions found in various hospitals, showing the lack of proper ventilation. 1500 w. Dom Engng—Feb., 1900. No. 32560 C.

Hot Air.

A Hot-Air Furnace Heating System. Illustrated description of a plant in a 66 x 43 ft. frame house, where provision is made for positive ventilation by special flues and dampers. 1000 w. Eng Rec—Feb. 10, 1900. No. 32427.

Pneumatics.

The Weight of Air. Information on the properties of air, and tables based on the laws of Boyle and Gay Lussac, which will prove useful in engineering calculations. 3300 w. Locomotive—Jan., 1900. No. 32541.

Shop Ventilation.

Heating and Ventilating Plant in the McCormick Harvesting Machine Company's Foundry. J. I. Lyle. Illustrated description of the fan system installed in a Chicago foundry. 1700 w. Foundry—Feb., 1900. No. 32496.

Station.

Ventilation and Heating of the Nashville Union Station. Illustrated description of an unusual plant in a 145 x 149 ft. building, 5 stories high. 3000 w. Eng Rec—Feb. 24, 1900. No. 32721.

MISCELLANY.

Color.

Color in Architecture. John Gemmell. Presented at convention of Ontario Assn. of Architects, Toronto. Considers the use of materials and the lessons to be learned from nature. 2800 w. Can Archt—Feb., 1900. No. 32715 C.

Fireproofing.

See Civil Engineering, Materials.

Lecture.

Progress in Architecture. Prof. Aitchison. First lecture on this subject to the students of the Royal Academy. 4000 w. Builder—Feb. 10, 1900. No. 32568 A.

CIVIL ENGINEERING

BRIDGES.

Cantilever.

Cantilever Bridge Over the Chéliff, Algeria (Pont à Jonction Centrale Partielle sur le Cheliff, Algérie). A. Dumas. With views showing the method of erection without false works, and data concerning the construction. The central span is 148 feet. 1800 w. Génie Civil—Feb. 3, 1900. No. 32603 D.

The Kaisersteg Bridge. H. Müller-Breslau, in *Zeitschrift für Bauwesen.* Illustrated description of a 573-ft. cantilever bridge with center hinge and a stiffening arch, in which the curves of the chords were determined by a unique method, described in detail. 800 w. Eng Rec—Feb. 17, 1900. No. 32523.

Continuous Girder.

Graphical Determination of the Pier Reactions of Continuous Girders of Constant Moment of Inertia (Zeichnerische Bestimmung der Stutzmomente Continuirliche Träger von Constantem Trägheitsmomente). L. Geusen. With numerous diagrams, adapted for a variety of cases occurring in practice. 2500 w. Zeitschr d Oesterr Ing u Arch Ver—Feb. 2, 1900. No. 32626 B.

Counterbracing.

Framed Girders with Diagonal Counterbracing (Fachwerkträger mit Gegendiagonalen). Karl Haberkalt. A discussion of the action of counterbraces in bridge trusses, maintaining that the desired stiffness can better be obtained by strengthening the main members. 3000 w. Oesterr Monatschr f d Oeffent Baudienst—Feb., 1900. No. 32653 D.

Railway Bridges.

Economies in Railway Bridge Design and Manufacture. J. Graham. Considers the subject in relation to bridges for export, in order that England may meet outside competition. 2200 w. Engr, Lond—Jan. 26, 1900. No. 32371 A.

The Lehigh Valley Railroad Bridge at Easton, Pa. Illustrated description of a structure consisting of 8 trusses and a 630-ft. viaduct approach. The truss spans are very much skewed at both ends, and the difficulties of alignment and centrifugal strains due to rapidly moving heavy trains, developed special features of construction which are explained in detail. 2600 w. Eng Rec—Feb. 10, 1900. No. 32418.

Rhine.

Arched Bridges Over the Rhine. Illustrated accounts of two remarkable bridges. Part first describes the Bonn bridge. 1500 w. Engng—Feb. 9, 1900. Serial. 1st part. No. 32585 A.

Skew.

The Designing of Skew Connection Details for Roof and Bridge Work. C. A. P. Turner. An illustrated discussion of methods used in determining dimensions. 4000 w. Eng News—Feb. 15, 1900. No. 32516.

South Africa.

The Frere and Tugela Bridges. Engravings giving an excellent idea of the wreckage of these bridges by the Boers, and information concerning the new bridges to replace them. 1000 w. Engng—Jan. 26, 1900. No. 32381 A.

Suspension.

Some Light Highway Suspension Bridges. Illustrated description of two structures of a type now used considerably in sparsely peopled regions. 1100 w. Eng Rec—Feb. 3, 1900. No. 32308.

Swing Bridge.

Construction of 175 ft. Counter Balanced Plate Girder Swing Bridge. W. A. Rogers. Illustrated description of the construction. 3800 w. Jour W Soc of Engs—Dec., 1899. No. 32306 D.

Design of a 175-ft. Counter Balanced Plate Girder Swing Bridge. Albert Reichmann. Illustrates and describes the novel features of probably the largest plate girder counter-balanced swing bridge ever built—on the C., M. & St. P. Ry. at Chicago. Operated by a 25-h.p. electric crane motor. 2000 w. Jour W Soc of Engs—Dec., 1899. No. 32305 D.

Operating Mechanism, Duluth and Superior Swing Bridge. Illustrated description of the electrical apparatus used in moving and locking a 2,000-ton swing span. 2200 w. Eng Rec—Feb. 24, 1900. No. 32722.

Swing-Bridges Over the River Weaver at Northwich. John Arthur Saner. Read at meeting of Inst. of Civ. Engs., London. Brief description of the two bridges and the motive power used. 1100 w. Builder—Feb. 3, 1900. No. 32463 A.

Test.

Destruction Test of the Erlenbach Bridge on the Black Forest Railway (Belastungsprobe bis zum Bruch der Erlenbachbrücke der Schwarzwaldbahn). F. Schüle. This lattice girder bridge had been in use for 30 years, and being superseded, was made the subject of an experimental test. 1200 w. Schweizerische Bauzeitung—Jan. 13, 1900. No. 32637 B.

Viaduct.

New Viaduct Construction on the C. & E. I. Ry. Illustrated detailed description of two steel viaducts, one over Little Saline Creek, and the other over Grasshopper Creek. 1200 w. Ry & Engng Rev—Feb. 17, 1900. No. 32557.

CONSTRUCTION.

Columns.

See Architectural Engineering, Design.

Embankments.

Building Large Embankments on the Boone County Ry. (C. & N. W. Ry. System). Information concerning the work, with illustration. 700 w. Eng News—Feb. 8, 1900. No. 32410.

Excavating.

A New Type of Excavating Machine. S. H. Lea. Illustrates a novel machine not yet placed on the market. It is known as the "Big Auger" and has not been successfully operated. 500 w. Eng News—Feb. 8, 1900. No. 32406.

Pile Drivers.

A Portable and Collapsible Pile Driver. Illustrated description of a driver with 40-ft. leads capable of working vertical or inclined piles on the sides or ends of its cars, which can be folded up into a very small space for transportation. 700 w. Eng Rec—Feb. 17, 1900. No. 32529.

Pneumatics.

Pneumatic Work. D. E. Moran. Address before the Central States Water-Works Assn. On the development of pneumatic foundation work. 2500 w. Compressed Air—Feb., 1900. No. 32393.

Retaining Wall.

Retaining Wall of Concrete with Metal Skeleton From *Le Génie Civil.* Illustrates and describes the construction of a temporary street below the general surface, in connection with the Paris Exposition. An application of the Henmebique system of combined concrete and steel was used. 700 w. Eng News—Feb. 15, 1900. No. 32517.

Subways.

Construction of the Ontario and Berri Street Subways, Brock Street Tunnel, and Notre Dame Street Viaduct. Stuart Howard. General description of the works named, with ten plates of drawings. 4800 w. Can Soc of Civ Engs (Adv. Proof)—Feb. 15, 1900. No. 32563 D.

Tunneling.

Municipal Tunnel Driving by Day Labor, Chicago. Paul G. Brown. Illustrated description of the methods employed by the city in completing, at much less than the contract price, tunnel operations which had been abandoned by the contractors. 1800 w. Eng Rec—Feb. 3, 1900. No. 32307.

The Work on the Simplon Tunnel (I Lavori pel Traforo del Sempione). A review of the progress made during the last three months of 1899, with details of the operation of the rock drills and other machinery. 1500 w. Gior d Lav Pubb e d Str Ferr—Feb. 7, 1900. No. 32678 B.

HYDRAULIC AND MARINE.

Bucket Pumps.

A Novel Type of Bucket Pump for Mines, Wells, Boreholes, etc. Illustrated description of an invention of Herbert Ashley, and a statement of its advantages. 1600 w. Ir & Coal Trds Rev—Feb. 2, 1900. No. 32473 A.

Canals.

New York's Canal Policy. What Shall It Be? Editorial discussion, presenting facts that may have influence, and discussing the claims made. 3000 w. Eng News—Feb. 8, 1900. No. 32409.

The Chicago Drainage Canal. Illustrates the great beartrap dam, and explains the benefit the channel will be to towns on its banks, where it will furnish power for various purposes. 1000 w. Fire & Water—Feb. 17, 1900. No. 32561.

The Erie Canal Problem. Editorial outlining the plans presented for consideration. 1400 w. Sci Am—Feb. 3, 1900. No. 32264.

The Great Lakes and New York Waterway. E. P. North. Discussion of the importance of canals in directing railway traffic. 2000 w. Eng Rec—Feb. 17, 1900. No. 32533.

The New Inland Waterway. J. A. Stewart. A technical description of the Chicago drainage canal, with a brief review of the considerations which led to its construction, and many illustrations. 3000 w. Sci Am—Feb. 17, 1900. No. 32504.

The New York Canals. A full abstract of a report of an investigation conducted with hitherto unequalled resources and advantages, by a special commission appointed by the Governor of New York. Also editorial on the importance of the investigation. 6200 w. Eng Rec—Feb. 3, 1900. No. 32311.

The Proposed Neutralization of the Isthmian Canal. Editorial discussion favoring the neutralization by international agreement, and giving reasons for the opinions expressed. 2500 w. Eng News—Feb. 22, 1900. No. 32708.

The Rhine-Elbe Canal and German Industries. On the proposed canal construction, which will furnish a fine system of inland waterways and greatly benefit the coal and iron industries. Map. 7100 w. Ir & Coal Trds Rev—Feb. 9, 1900. No. 32569 A.

What Shall New York Do With Its Canals? The report of the Governor's advisory committee in full. 16000 w. Eng News—Feb. 1, 1900. No. 32355.

Dams.

A Large Crib Dam, Butte, Mont. Describes a structure 319 ft. long, 42 ft. high, and built of round fir logs in cribs 8 ft. square. 1800 w. Eng Rec—Feb. 3, 1900. No. 32309.

The Silting-Up of Lake McDonald and the Leak at the Austin Dam. Thomas U. Taylor. Information relating to the amount of silt deposited, with explanation of theory, an illustrated description of leaks occurring and means of remedying them. 1600 w. Eng News—Feb. 22, 1900. No. 32711.

Docks.

Concrete Dock Construction at the South Works of the Illinois Steel Company. Victor Windett. Illustrated description of the repairs, rebuilding, etc., with account of cost and satisfactory results. 6300 w. Jour W Soc of Engs—Dec., 1899. No. 32303 D.

U. S. Floating Dry Dock at Algiers, La. Drawings and description showing the general construction of this large dock and the approaches, and discussing interesting features. 2500 w. Marine Engng—Feb., 1900. No. 32386 C.

Regulating Dam in the San Juan River (Digue Nivelador, Rio San Juan). José S. Corte. A general description of the dam and of its partial destruction in Dec., 1898, with numerous photographs. 2500 w. 3 plates. La Ingeneria—Dec. 31, 1899. No. 32679 H.

See Mining and Metallurgy, Mining.

Dredge.

American Dredge in Russia. An interesting account of the trials of the Beta, which far exceeded the contract demands. 1200 w. U. S. Cons Repts, No. 647—Feb. 6, 1900. No. 32382 D.

The Kretz Suction Dredge (Kretz'sche Spülbagger). An illustrated description of this improved dredge, in which powerful jets of water are used to disintegrate the material and enable the suction currents to remove it. 3000 w. Oesterr Monatschr f d Oeffent Baudienst—Jan., 1900. No. 32651 D.

Floods.

Flood Damage to the Hudson River Passenger Bridge and Station of the Delaware & Hudson Ry., at Albany, N. Y. An illustrated account of the damage to property. 1100 w. Eng News—Feb. 22, 1900. No. 32709.

Harbours.

Maritime Installation of the Port of Ostend (Installations Maritimes du Port d'Ostende). O. Watrin. A general description of the improved harbour works, with plates showing the construction of the docks and quay walls. 4000 w. 3 plates. Rev Univ des Mines—Jan., 1900. No. 32632 G.

Merchant Shipping in the Harbour of Vladivostock (Die Handelsschiffahrt im Hafen von Wladiwostok). F. Theiss. With map and photographs of the terminal of the Siberian railway, and an account of the business now handled at the port. 1800 w. Oesterr Monatschr f d Oeffent Baudienst—Feb., 1900. No. 32653 D.

Northern Harbors Kept Open. Robert Runneberg. On the American system of building ice-breaking boats, and their use in keeping harbors open. 800 w. Am Mfr & Ir Wld—Feb. 22, 1900. No. 32714.

The New Harbour Work at Bruges (Nouveaux Ports de Bruges). J. Nyssens-Hart. An account of the conduct of the improvement works, with especial reference to the machinery and methods employed in connection with the heavy masonry construction. 3000 w. 1 plate. Rev Univ des Mines—Jan., 1900. No. 32633 G.

The Port of Dunkirk (Le Port de Dunkerque). A description of the new channel and docks, and the effect of improved facilities upon traffic. 3000 w. 1 plate. Rev Univ des Mines—Jan., 1900. No. 32634 G.

Lake Nicaragua.

An Assumed Inconstancy in the Level of Lake Nicaragua; a Question of Permanency of the Nicaragua Canal. Angelo Heilprin. A discussion of the important bearing on the proposed canal, giving instances of marked oscillation in other lakes. 2500 w. Sci Am—Feb. 24, 1900. No. 32701.

Lock Gates.

The Electrical Operation of the New Sea Lock Gates at Ymuiden (Elektrische Bewegungseinrichtungen der Neuen Seeschleuse zu Ymuiden). A description of the electrical plant, and an account of the manner in which the heavy gates of this new lock in Holland are successfully operated. 1800 w. Zeitschr d Oesterr Ing u Arch Ver—Jan. 19, 1900. No. 32623 B.

Locks.

The Proposed Pneumatic Balance Locks for the Erie Canal. Illustrated description, explaining the principles upon which the locks are operated. 1700 w. Sci Am—Feb. 3, 1900. No. 32267.

Niagara.

Discharge Measurement of the Niagara River at Buffalo, N. Y. Clinton B. Stewart. Describes the apparatus and methods used, the computations, etc. Ill. 10500 w. Jour W Soc of Engs—Dec., 1899. No. 32304 D.

Pipe Line.

The Coolgardie Pipe Line. A description of a steel force main 328 inches long, now under construction to supply the gold fields of West Australia. The pipe is 30 inches in diameter and provided with special forms of longitudinal and round joints. 3500 w. Eng Rec—Feb. 24, 1900. No. 32720.

Reservoirs.

Constructing the Jerome Park Reservoir. Illustrated description of the methods employed in constructing a 2,000,000,000 gal. reservoir for the New York water-works; the excavation is mainly by steam shovels, with blasting, and the concrete plant is out of the ordinary. 2500 w. Eng Rec—Feb. 17, 1900. No. 32524.

Reservoirs in the Vosges (Die Stauweiher in den Vogesen). Thomas Hofer. Describing several important reservoirs in the Vosges mountains in Alsace-Lorraine, with sections of the dams, and plans of the water areas. 3000 w. 2 plates. Oesterr Monatschr f d Oeffent Baudienst—Jan., 1900. No. 32649 D.

The Relation of Reservoirs to Parks. Frederick Law Olmsted, Jr. An illustrated article giving many suggestions for the treatment of distributing reservoirs, so that they may add to the beauty of their surroundings, as well as serve for holding water. 5500 w. Munic Engng—Feb., 1900. No. 32384 C.

Various Reservoirs in Lorraine, Belgium and France (Verschiedene Stauweiheranlagen in Lothringen Belgien und Frankreich). Thomas Hofer. A general description of reservoirs and canals inspected by the author, with plates showing dam and channel construction. 4000 w. 3 plates. Oesterr Monatschr f d Oeffent Baudienst—Feb., 1900. No. 32652 D.

River Improvements.

Proposed Improvements of the Southwest Pass at the Mouth of the Mississippi. Brief sketch of the proposed work, with map. 2100 w. Eng News—Feb. 15, 1900. No. 32519.

Water Meters.

Water Meters of the Present Day: With Special Reference to the Small Flows and Waste in Dribbles. William Schönheyder. Read before the Inst. of Mech. Engs. Divides the meters in use into six classes, treating of each and noting the purpose and advantages of each type. Ill. 5000 w. Engr, Lond—Feb. 2, 1900. No. 32469 A.

Water Purification.

Ozone as a Water Purifier. A review of the experiments of Th. Weyl with apparatus on a commercial scale, together with comments of German engineers on the utility of ozone in water purification. 2200 w. Eng Rec—Feb. 3, 1900. No. 32313.

The Relative Values of Ozone and Slow Sand Filtration as a Means of Purifying Water. Abstract translations from the German, by Allen Hazen. Discussion of Dr. Weyl's paper. 7500 w. Eng News—Feb. 8, 1900. No. 32408.

Water Supply.

Local Government and Its Relation to Parish Water Supply and Sewerage. W. O. E. Meade-King. Discusses small communities in England, aiming to show that wealth as well as health is increased by proper sanitation. Also discussion. 6900 w. Jour Soc of Arts—Jan. 26, 1900. No. 32356 A.

London Water-Supply. Editorial, outlining the prominent features of the report of the Royal Commissioners, and giving comments on the conclusions reached. 2000 w. Engr, Lond—Jan. 26, 1900. No. 32375 A.

The London Water Commission Report. Brief statement of the points dealt with in the final report, with editorial discussion of the conclusions. 6000 w. Builder—Feb. 3, 1900. No. 32460 A.

Water-Waste.

A British View of Water-Waste. Extracts from the report of the Llandaff Commission on the London water-works, in which a supply of 42 U. S. gals. per capita daily is held to indicate waste. 2500 w. Eng Rec—Feb. 17, 1900. No. 32525.

Water-Works.

Florence, Col., Water-Works. R. P. Garrett. Illustrated description of a plant noteworthy for having a submerged dam to force ground water to the surface, and a gravity main about 7 miles long, of vitrified clay pipe. 1500 w. Eng Rec—Feb. 10, 1900. No. 32419.

Outlet Valves, Burrator Reservoir, Plymouth, England. Illustrated description of 3-beat cage valves at the outlets of pipes 25 to 36 ins. in diameter, by the use of which a gate chamber was made unnecessary. 600 w. Eng Rec—Feb. 10, 1900. No. 32422.

The Latest Report on the London Water Companies. A review of the report of the Llandaff Commission, which recommends the purchase of the existing private plants. Gives figures of the nominal and market value of the private plants and estimates of the cost of constructing additional works for a total supply of 504,000,000 gals. 2000 w. Eng Rec—Feb. 10, 1900. No. 32415.

The Relative Responsibilities of Engineer and Contractor. Review of a decision of the Pennsylvania Supreme Court that a contractor, who builds a reservoir in accordance with plans, speci-

fications and engineering directions, cannot be held liable for the failure of the reservoir to hold water. 700 w. Eng Rec—Feb. 17, 1900. No. 32521.

The Water Works of the City of Prenzlau (Das Wasserwerk der Stadt Prenzlau). H. Scheven. The supply is obtained partly from springs and partly by the use of filtered water from Lake Uecker. Details of the filtering and aerating plant are given. 2000 w. Zeitschr d Ver Deutscher Ing—Jan. 13, 1900. No. 32611 D.

The Water Works of the X. District, Vienna (Wasserwerk der Stadt Wien in X. Bezirk). Fr. Borkowitz. An illustrated description of this new secondary pumping station, with full details of the compound pumping engines and water tower, and data and results of tests. 3000 w. 4 plates. Zeitschr d Oesterr Ing u Arch Ver—Jan. 26, 1900. No. 32625 B.

MATERIALS.

Buckling.

The Correct Formula for Buckling (Die Richtige Knickungsformel). J. Kübler. An analytical and graphical comparison of the formulas of Euler, Rankine, and Tetmaier, and the derivation of a new formula claimed to represent the relation of the forces correctly. Serial, Part I. 1800 w. Zeitschr d Ver Deutscher Ing—Jan. 20, 1900. No. 32614 D.

Cements.

Hydraulic Cements. William S. Macharg. From *The Building Arts.* Comments on the new uses to which this material has been applied. Briefly reviews the history of the modern product, and gives information concerning it. 2000 w. Sci Am Sup—Feb. 24, 1900. No. 32700.

The Measurement of the Variations in Volume of Hydraulic Cements (Mesure des Variations de Volume des Liants Hydrauliques). M. Deval. A general report upon the tests made by a committee of the Society, with tables of the results and diagrams showing the behaviour of various cements. 10000 w. Bull de la Soc d'Encour—Jan. 31, 1900. No. 32609 G.

The New Works of the Coplay Cement Company. Illustrated description of a plant making 1600 bbls. of Portland cement daily. Traces the progress of the material from the quarry to the storehouse for the finished product, and describes the apparatus and its arrangement. 2400 w. Eng Rec—Feb. 27, 1900. No. 32717.

The Softening of Portland Cement Plaster. An account of the destruction of the lining of water basins in Leipzig and other German cities by the carbonic acid in the water. 1000 w. Eng Rec—Feb. 3, 1900. No. 32312.

Fireproofing.

Wood Fireproofing. Illustrates and describes the process of the American Wood Fireproofing Company of New York. 1000 w. Fire & Water—Feb. 24, 1900. No. 32732.

Quicksand.

Quicksand. A report of statements by a number of engineers, including an analysis of the physical properties of quicksand, and a statement of its true nature. 1700 w. Eng Rec—Feb. 10, 1900. No. 32428.

Tests.

Tests of Small Model Cement Arches to Determine the Value of Tie Rods. Daniel B. Luten. Illustrated description of these tests and discussion of the results. 1400 w. Eng News—Feb. 15, 1900. No. 32515.

See Bridges.

Timbers.

Wood Preserving in Germany. A. G. Wanier. Describes the Hasselmann process and quotes from authorities and experts concerning its advantages and value. 2800 w. R R Gaz—Feb. 9, 1900. No. 32451.

MUNICIPAL.

Garbage.

The Barren Island Garbage Reduction Works, Greater New York. An account of the disposition of the garbage of Greater New York, and an illustrated detailed description of the plants on Barren Is. Also editorial. 7700 w. Eng News—Feb. 1, 1900. No. 32351.

Highway Traffic.

The Restriction of Traffic on Highways. A review of a decision of the Maine Supreme Court that it is unreasonable to force heavily laden wagons from improved roadways, unless suitable roads are provided for them. 700 w. Eng Rec—Feb. 10, 1900. No. 32416.

Pavements.

Brick Pavements from a Contractor's Point of View. George R. Grimes. Abstract of paper read at meeting of the National Brick Mfrs. Assn. Gives the most satisfactory methods of laying brick pavements. 2500 w. Eng Rec—Feb. 24, 1900. No. 32718.

Creosoted Wood Block Pavements in Indianapolis. M. A. Downing. Read before the Am. Soc. for Munic. Imps. Gives an account of the use of this pavement in city named and considers it a success from every point of view. 1500 w. St Ry Rev—Feb. 15, 1900. No. 32510 C.

Brick Paving in Iowa. A statement of the elaborate tests being conducted in that State on the physical and chemical properties of paving brick, the methods

of testing them, and the actual resistance of the various brands to travel, in different cities of the State. 2500 w. Eng Rec—Feb. 3, 1900. No. 32314.

Philadelphia.

Philadelphia: What Are Its Needs? Discussion, introduced by H. V. B. Osbourn, of the municipal improvements desirable in this city. Ill. 5000 w. Pro Engs' Club of Phila—Feb., 1900. No. 32744 D.

Quarantine.

Sanitary Methods During the Bubonic Plague in Honolulu. Describes the measures taken by the Board of Health, particularly in the Chinese quarters. 1200 w. Eng Rec—Feb. 17, 1900. No. 32527.

Refuse.

The Modified Horsfall Crematory. Illustrated description of a form of destructor designed to burn very wet city refuse, like swill, sewage sludge or night soil. 700 w. Eng Rec—Feb. 3, 1900. No. 32319.

Roads.

Modern City Roadways. Nelson P. Lewis. Illustrates and discusses the different kinds of paving in general use and the kinds most favored in various cities. 3500 w. Ap Pop Sci M—March, 1900. No. 32736 C.

Santiago.

Sanitary Conquest of Santiago. From *Chicago Sunday Tribune.* An account of the work that has been necessary to make the city a safe dwelling place. 3000 w. Dom Engng—Feb., 1900. No. 32559 C.

Sewage Disposal.

Bacterial Sewage Disposal at East Cleveland. Illustrated description of a plant for treating 150,000 gals. of sewage daily by the Waring system of preliminary filtration, aeration and final filtration. 1600 w. Eng Rec—Feb. 10, 1900. No. 32420.

Results Obtained with the Ames Sewage Disposal Works. A statement of the leading facts found by chemical and bacteriological examinations of the raw and purified sewage at a plant using some storage and then intermittent filtration. 1800 w. Eng Rec—Feb. 24, 1900. No. 32719.

Sewage Disposal at Chichester, England. James H. Fuertes. Illustrates and describes works to store, clarify by chemical treatment, and filter the sewage of a sea-coast town of 4,000 population. 900 w. Eng Rec—Feb. 10, 1900. No. 32421.

Sewage Filtration Through Coal. A review of experiments at Lichfield and Wolverhampton yielding new information on the value of coal for treating the effluents of chemical and septic tanks. 1800 w. Eng Rec—Feb. 3, 1900. No. 32310.

The Iowa State College Sewage Disposal Plant. Illustrated description of works on the intermittent filtration system, in which a partial septic action is obtained by preliminary storage of the sewage. 2500 w. Eng Rec—Feb. 17, 1900. No. 32522.

The Scott-Moncrieff System of Sewage Disposal. Detailed description of the process and of the steps by which its present condition has been reached. Ill. 2500 w. Engr, Lond—Jan. 26, 1900. No. 32373 A.

Street Cleaning.

Street Cleaning Statistics for Forty American Cities. Tabulated information compiled by Andrew Rosewater, of Omaha, Neb. 600 w. Eng News—Feb. 22, 1900. No. 32712.

ELECTRICAL ENGINEERING

COMMUNICATION.

Police Telegraphs.

A New Electrical Police Signaling System. Illustrated description of the Davis system and statement of the advantages claimed. 1000 w. Fire & Water—Feb. 10, 1900. No. 32486.

Fire Alarm and Police Telegraph System, Los Angeles. Illustrated description of a fine automatic system in Los Angeles, Cal., comprising 14 box circuits and 10 gong circuits for the fire alarm system, and 4 signal circuits for the police telegraph system. 1400 w. Elec Wld & Engr—Feb. 17, 1900. No. 32536.

Self Induction.

See Measurement.

Space Telegraphy.

Recent Progress in Wireless Telegraphy. G. Marconi. Abstract of a discourse delivered at the Royal Inst., with editorial comment. On problems recently solved and developments of the last few months. Ill. 5500 w. Elect'n, Lond—Feb. 9, 1900. No. 32566 A.

The Possibilities of Wireless Telegraphy. A topical discussion introduced by Reginald A. Fessenden. Ill. 17400 w. Trans Am Inst of Elec Engs—Dec., 1899. No. 32737 D.

Telephones.

A New Telephone System for Party Lines. Jul. H. West. Illustrates and describes a system allowing the telephones

of several subscribers to be connected to the exchange by one common party line. It contains a device for locking all stations on the line except the one in use. 1800 w. Elect'n, Lond—Feb. 2, 1900. No. 32479 A.

Selective Telephone Signals. H. S. Webb. Describes and illustrates a new selective signalling system recently patented by J. A. Barrett. 2500 w. Am Elect'n—Feb., 1900. No. 32291.

The Paris Telephone System (Le Téléphone à Paris). A. Dennery. A very complete account of the new central station at Paris, showing the arrangement of connections and switchboards, and methods of operating, with numerous illustrations. Two articles, 4500 w. Génie Civil—Jan. 20, 27, 1900. No. 32600 each D.

Toll Lines.

The Construction of Toll Lines. Illustrated detailed description of this branch of telephone work, discussing some of the difficulties to be overcome. 5500 w. Tel Mag—Feb., 1900. No. 32739.

DISTRIBUTION.

Alternating Currents.

The Drop in Alternating-Current Wires. Cecil P. Poole. Presenting facts bearing on this subject and discussing methods of computing. 1700 w. Elec Wld & Engr—Feb. 21, 1900. No. 32727.

Distributing Station.

Central Distributing Station of the Philadelphia Electric Company. C. Walton Swoope. Illustrated description of the system in use since the consolidation. It differs from those in operation in other cities in that more than one permanent generating station will be maintained. 2000 w. Elec Wld & Engr—Feb. 24, 1900. No. 32725.

Three-Wire System.

Improvements in the Three-Wire System. Alton D. Adams. Notes recent improvements which the writer thinks ensure for this system a tendency to displace all other systems of public distribution. 2500 w. Am Elect'n—Feb., 1900. No. 32289.

The Bromley and Chislehurst Electric Lighting System. Illustrated detailed description. 3400 w. Elect'n, Lond—Jan. 26, 1900. No. 32360 A.

Underground Construction.

Electrical Underground Construction. George B. Springer. Illustrated description of various systems, and methods of carrying out the work, with related information. 5000 w. Jour W Soc of Engs —Dec., 1899. No. 32302 D.

Wiring.

The Electric Wiring of Buildings. W. A. Chamen. Abstract of a paper read before the Inst. of Engs. and Shipbuilders, at Glasgow. Considers the different systems in use and their variations, and discusses what is best in the interests of safety. 4600 w. Elect'n, Lond—Feb. 2, 1900. No. 32481 A.

ELECTRO-CHEMISTRY.

Copper Tubes.

An Electrolytic Centrifugal Process for the Production of Copper Tubes. Sherard Cowper-Coles. Read before the Inst. of Elec. Engs. Discusses the progress of electrolytic copper refining, describing the methods for improving the physical properties, the centrifugal process developed by the author, etc. Ill. 5500 w. Elect'n, Lond—Feb. 9, 1900. No. 32565 A.

Electro-Galvanizing.

Some Notes on Electro-Galvanizing. Sherard Cowper-Coles. Illustrates and describes the process, and notes some of its applications. 1600 w. Ind & Ir—Feb. 2, 1900. No. 32477 A.

Electrolysis.

The Decomposition of Common Salt (Zur Kochsalzzerlegung). R. Lorenz and H. Wehrlin. A contribution from the electro-chemical laboratory of the Zürich Polytechnic, giving the results of experiments upon the electrolytic production of hypochlorites and chlorates by the decomposition of common salt. Three articles, 7500 w. Zeitschr f Elektrochemie—Jan. 25, Feb. 1, 8, 1900. No. 32662 each D.

Review.

Electrochemistry in the Year 1899 (Die Elektrochemie im Jahre, 1899). Dr. M. Krüger. A general review of progress in various branches of the art during the past year. 3500 w. Elektrochemische Zeitschr—Feb., 1900. No. 32666 G.

Switchboard.

A Switchboard for the Electrolytic Laboratory (Schalttafeln für Elektrolytische Laboratorien). Fr. Klingelfuss. A convenient design of switchboard for use with continuous lighting current in connection with a small accumulator system. 1200 w. Zeitschr f Elektrochemie—Jan. 18, 1900. No. 32661 D.

Voltaic Cell.

The Theory of the Voltaic Cell. Appended to Prof. A. Righi's lecture on Volta, delivered at Como. An explanation of various phenomena, and of certain theories. 6000 w. Elec Rev, Lond—Feb. 9, 1900. No. 32567 A.

ELECTRO-PHYSICS.

Asynchronous.

The Theory of Asynchronous Motors

(Zur Theorie der Asynchronmotoren). Julius Heubach. A graphical treatment of the general theory of non-synchronous motors; both three-phase and single-phase motors being considered. Two articles, 10,000 w. Elektrotech Zeitschr—Jan. 25, 1900. No. 32654 each B.

Engraving.

An Electrical Engraving Process. N. S. Amstutz. Illustrated description of a mechanism called the acrograph, which does for light what the phonograph does for sound. Specimens of work are also given. 4400 w. Elec Wld & Engr—Feb. 17, 1900. No. 32535.

Hysteresis.

The Hysteretic Qualities of Iron Viewed from the Molecular Magnet Standpoint. Dr. Samuel Sheldon. An interesting account of experiments with watch-charm compass magnets. 1100 w. Elec Wld & Engr—Feb. 10, 1900. No. 32431.

Radiography.

A Method of Measuring the Velocity of Röntgen Rays (Une Methode de Mesure de la Vitesse des Rayons Röntgen). Bernard Brunhes. An adaptation of the property of the X rays upon potential explosives for measuring the velocity. The ordinary methods are not applicable to rays which cannot be reflected. 1200 w. Comptes Rendus—Jan. 15, 1900. No. 32629 D.

Resistance.

The Permanent Modifications of Metallic Wires and the Variation in their Electric Resistance (Les Modifications Permanentes des Fils Metalliques et la Variation de leur Resistance Electriques). H. Chevalier. A communication to the French Academy, giving the results of experiments made at the Physical Laboratory at Bordeaux upon the influence of variations of temperature upon resistance. 1000 w. Comptes Rendus—Jan. 15, 1900. No. 32628 D.

GENERATING STATIONS.

Accumulators.

A Graphical Investigation of the Action of Storage Batteries (Graphische Ermittelung der Leistung von Pufferbatterien). Moritz Kohn. A discussion of the action of a storage battery when used in parallel with a generator, the curves of the dynamo and the battery being combined. 2000 w. Elektrotech Zeitschr—Jan. 25, 1900. No. 32655 B.

Pressure Ratios in Accumulator Plants (Spannungsverhältnisse bei Akkumulatoren-Anlagen). E. Schiff. Discusses the most advantageous rates for charging and discharging storage batteries. 1000 w. Elektrochemische Zeitschr—Feb., 1900. No. 32665 G.

See Mechanical Engineering, Automobilism.

Accumulator Plates.

A Method of Determining the True Surface of Accumulator Plates (Ueber eine Methode zur Bestimmung der Wahren Obenflächen von Akkumulator platten). Konrad Norden. Discussing a method of determining the effective area of any form of accumulator plate by the volume of current yielded, and showing how to apply data thus determined to subsequent designs. 3500 w. Zeitschr f Elektrochemie—Feb. 1, 1900. No. 32663 D.

Austria.

The New Plant of the Witkowitz Company at Dombrau, Austria (Les Nouvelles Installations de la Cie de Witkowitz aux Mines de Dombrau, Austriche). H. Schmerber. A general description, with plate, showing the electric plant in the picking and sorting department of these important Austrian coal mines. 2000 w. 1 plate. Génie Civil—Jan. 20, 1900. No. 32601 D.

The Status of the High Pressure Current Industry in Austro-Hungary (Die Lage der Starkstromindustrie in Oesterreiche-Ungarn). Emil Honigmann. A review of the work of the year 1899, with a complete table of existing plants, giving commercial and technical data of value. 7500 w. Elektrotech Zeitschr—Feb. 8, 1900. No. 32660 B.

Bromley, Kent.

An English Direct Current High Tension Central Station. Illustrated description of a plant recently installed at Bromley, Kent, distributing direct current at high voltage and transforming to service voltage by means of dynamotors. 2000 w. Elec Wld & Engr—Feb. 17, 1900. No. 32534.

Design.

The Designing of Electrical Generating Stations. A. Roberts. Read before the Soc. of Archts., England. Describes a typical station, its construction, and arrangements. 4700 w. Arch't, Lond—Jan. 26, 1900. No. 32357 A.

Dynamos.

Notes on Commutatorless Dynamo Design. H. E. Heath. Describes several forms, giving illustrations, and pointing out the advantage of this type for the production of large currents at low voltages. 1600 w. Elec Wld & Engr—Feb. 10, 1900. No. 32430.

Govan.

Govan Electricity Supply Works. Illustrated description of a three-wire continuous-current system with 250 volts on each side of the middle wire. 2300 w. Elect'n, Lond—Feb. 2, 1900. No. 32480 A.

Induction Motor.

The Polyphase Induction Motor. Ralph D. Mershon. Read at the Milwaukee meeting of the Northwestern Elec. Assn. Explains the salient points in the theory of the induction motor without using mathematics or complicated diagrams, but making clear the underlying principles. Ill. 4000 w. Elec Wld & Engr—Feb. 3, 1900. Serial. 1st part. No. 32350.

London.

Plant of London Metropolitan Electric Supply Company. Illustrates and describes the steam engines and generators, and switchboard. 1600 w. Elec Wld & Engr—Feb. 3, 1900. No. 32349.

Massena, N. Y.

The Power House of the St. Lawrence Power Company, Massena. Illustrated description of the station on the Grasse River, which is designed for an ultimate capacity of 150,000 h.p., half again as much as the capacity of the Niagara Plant at present. The switchboard details are particularly novel. 1800 w. Eng Rec—Feb. 10, 1900. No. 32417.

Power Plant.

A One-Hundred-Thousand Horse-Power Plant. Illustrated detailed description of the power station of the Third Avenue Railroad Company of New York. 5700 w. Power—Feb., 1900. No. 32262.

Regulator.

New Automatic Pressure Regulator (Neuer Selbstthätiger Spannungsregulator). Emil Dick. The regulator is operated by a solenoid acting upon a field resistance. The weight of the solenoid core is counteracted by floating it in mercury. 3500 w. Eletrotech Zeitschr—Jan. 25, 1900. No. 32656 B.

Standardization.

The Standardization of Electrical Engineering Plant. R. Percy Sellon. Read before the Inst. of Elec. Engs., England. Presents the importance and advantages from an English standpoint. 3000 w. Ind & Ir—Feb. 9, 1900. No. 32573 A.

Test.

Test of an Electric Generating Set in the State, War and Navy Building, Washington. G. W. Baird. The experiments were made on a 60 K. W. direct-current compound condensing plant. 1000 w. Eng Rec—Feb. 17, 1900. No. 32531.

HEATING AND WELDING.

Annealing.

The Electric Process of Annealing Armor-Plate in the Construction of War-Ships. Charles J. Dougherty. Treats of the process of the Thomson Electric-Welding Co., of Lynn, Mass. Illustrated description, with discussion. 3000 w. Pro Engs' Club of Phila—Feb., 1900. No. 32-743 D.

Furnaces.

Electric Furnaces with Especial Reference to the Production of Calcium Carbide (Ueber Elektrische Oefen, besonders mit Rücksicht auf die Darstellung von Calcium Carbid). Birger Carlson. An examination of the electrical, thermal, and chemical conditions entering into the production of carbide and the best design of furnace for the purpose. Serial. Part 1. 3000 w. Zeitschr f Elektrochemie—Feb. 8, 1900. No. 32664 D.

Rail Welding.

The Goldschmidt Process of Rail Welding. Abstracts of two papers describing this novel and interesting method. Ill. 2000 w. St Ry Jour—Feb. 3, 1900. No. 32332 D.

LIGHTING.

Arc.

Alternating-Current Arc Lighting. E. P. Warner. Read before the Chicago Elec. Assn. Briefly reviews the early history of arc lighting and considers modern practice. 3300 w. Elec Rev, N. Y.—Jan. 31, 1900. No. 32283.

Incandescent.

The Incandescent Electric Light. Gives interesting history, claiming that the original discovery of this light was in Toronto, Canada, and that Dr. Woodward's patent antedates the patent of T. A. Edison and was purchased by him. 3000 w. Can Elec News—Feb., 1900. No. 32507.

Lightning.

The Effects of Lightning Upon Electric Lamps. Sydney Webb and G. G. Stokes. Gives illustrations showing effects obtained when attempting to photograph lightning in a field including arc lamps. 2800 w. Nature—Feb. 8, 1900. No. 32-562 A.

Nernst Lamp.

The Predecessors of Nernst (Les Précurseurs de Nernst). L. de Somzée. A brief review of the early inventions in incandescent electric lighting, based upon the conductivity of refractory substances when heated; discussing the extent to which these anticipated the Nernst lamp. 1200 w. L'Electricien—Jan. 20, 1900. No. 32668 B.

Primary System.

Electric Lighting from Primary Batteries. F. E. Woodford. On means of lighting residences in rural districts, and other uses of electricity. 1800 w. Am Elect'n—Feb., 1900. No. 32290.

MEASUREMENT.

Electrometer.

The Addenbrooke Electrometer. Il-

lustrated description of G. L. Addenbrooke's system of alternating-current measurement. 1800 w. Elec Eng, Lond —Feb. 2, 1900. No. 32456 A.

Magnetic Fields.

The Ayrton-Mather Portable Field Tester. Illustrates and describes an apparatus consisting of a search-coil and a ballistic galvanometer, and claiming to obtain angular deflections to 800°. 700 w. Elec Wld & Engr—Feb. 10, 1900. No. 32432.

Meter.

Multiple Dial Electric Meter (Compteur Horaire d'Electricité à Cadrans Multiples). M. Aliamet. A description of the Villy meter. One clock work mechanism is provided with a number of dials, each of which may be connected with a different circuit. 1200 w. L'Electricien—Jan. 20, 1900. No. 32667 B.

Self Induction.

Measurements of the Self-Induction of Submarine Cables. Dr. F. Breisig. From the *Elektrotechnische Zeitschrift*. A communication from the Testing Office of the German Government Telegraphs. Describes the method of measurement, the conductors tested, results, etc. 2500 w. Elect'n, Lond—Feb. 2, 1900. No. 32482 A.

Units.

A Proposed System of Units. Reginald A. Fessenden. Shows the desirability of having electrical units, rationalized, and suggests an intermediate solution of the difficulty. Also editorial. 3500 w. Elec Wld & Engr—Feb. 24, 1900. No. 32726.

POWER APPLICATIONS.

Canal Traction.

Electric Traction on Canals (La Traction Electrique sur les Canaux). R. Dubreuil. With descriptions and illustrations of the various devices used in France, Germany, and elsewhere, and data of the results of practical operation. 3000 w. Revue Technique—Jan. 10, 1900. No. 32604 D.

Crane.

Electric Radial Crane of 150 Tons Capacity at the Harbour of Bremerhaven (Grue Pivotante Electrique de 150 Tonnes, du Port de Bremerhaven). A full detailed description of this powerful electric crane, of 72 feet maximum radius, and electric movements throughout. 2000 w. 1 plate. Génie Civil—Feb. 3, 1900. No. 32602 D.

Factory Plants.

Continuous and Multiphase Power Plants for Factory Use. Examines the advantages and difficulties of multiphase power plants, concluding that from the plants inspected it was difficult to perceive any advantage over the continuous system. 2500 w. Elec Rev, Lond—Jan. 26, 1900. No. 32361 A.

Lock Gates.

See Civil Engineering, Hydraulic.

Locomotive.

See Street and Electric Tramways.

Powder Works.

Electrical Equipment of United States Government Powder Factories. Illustrates and describes the plant being installed at the Indian Head factory. 1800 w. Engng—Jan. 26, 1900. No. 32379 A.

Printing.

The Electrical Equipment of the Printing Establishment of the "St. Louis Republic." George A. Damon. Illustrated detailed description of the plant. 2500 w. Am Elect'n—Feb., 1900. No. 32285.

Steering Gear.

Electrical Steering Gear for Ships. Illustrations and explanation of the machinery and wiring and how it works. Four Russian war ships are to be fitted with the electrical steering gear. 1800 w. Marine Rev—Feb. 8, 1900. No. 32449.

TRANSMISSION.

Conductors.

A Graphical Representation of the Flow of Alternating Currents in Long Conductors (Ueber die Graphische Darstellung des Verlaufes von Wechselströmen längs Langer Leitungen). Dr. F. Breisig. A paper read before the Berlin Electrotechnical Society, giving an analytical and graphical discussion, and describing a model for illustrating the wave action. 6000 w. Elektrotech Zeitschr—Jan. 25, 1900. No. 32657 B.

Mount Whitney.

The Mount Whitney Power Transmission. Robert McF. Doble. Interesting illustrated description of this modern and finely equipped installation, with account of its construction. 6500 w. Jour of Elec —Jan., 1900. No. 32498.

Power Economics.

The Economics of Long Distance Electric Power Transmission. Alton D. Adams. Discusses the prospectus of a company in Western Illinois, showing the falsity of the claims made, and of similar claims concerning the transmission of power over long distances. 2200 w. Eng News—Feb. 1, 1900. No. 32353.

Transformation.

The Transformation of Niagara Power Into Three-Wire Direct Current by the Buffalo General Electric Company. Illustrations with complete description of circuits and explanations of unusual alternating-current phenomena involved. 5500 w. Am Elect'n—Feb., 1900. No. 32284.

GAS ENGINEERING

Acetylene.

The Official Report of the Budapest International Acetylene Exhibition and Congress. Comments on this report, and information gathered from it. 1500 w. Engr, Lond—Feb. 2, 1900. No. 32466 A.

The Second International Acetylene Exposition at Budapest, 1899 (Die Zweite Internationale Acetylen-Austellung in Budapest, 1899). Karl Neudeck. A complete review of the exposition, with plan of the building, and illustrated descriptions of the various exhibits, forming a complete account of the present status of the subject. Three articles, 8000 w. Zeitschr d Oesterr Ing w Arch Ver—Jan. 12, 19, 26, 1900. No. 32622 each B.

Address.

Inaugural Address of Mr. Henry O'Connor, before the Society of Engineers. Observations on the developments in gas engineering during recent years. 8500 w. Jour Gas Lgt—Feb. 6, 1900. No. 32483 A.

Coal-Gas.

The Manufacture of Coal-Gas. Illustrated detailed description of process using fuel-gas for heating the retorts, and describing various devices in use. 2500 w. Sci Am Sup—Feb. 10, 1900. No. 32405.

Deposits.

The White Deposit on Ceiling-Protectors and on the Chimneys of Incandescent Gas Burners. On the researches made by Dr. C. Killing and published in the *Journal für Gasbeleuchtung*. 2000 w. Jour Gas Lgt—Feb. 13, 1900. No. 32716 A.

Ferrocyanides.

A Method for the Estimation of Ferrocyanides in Old Purifying Material. E. Donath and B. M. Margosches, in *Zeitschrift für Angewandte Chemie*. Describes the process and method of applying to old purifying material. 1200 w. Am Gas Lgt Jour—Feb. 19, 1900. No. 32538.

Fuel Gas.

Some Notes on Gas as a Fuel. Discusses coal and its combustion and the loss in heating power in making "producer" gas. 2200 w. Ir & Coal Trds Rev—Feb. 2, 1900. No. 32470 A.

Furnace Gas.

The Use of Blast Furnace Gas for Power Purposes. W. H. Booth. Considers the important facts when it is proposed to utilize blast-furnace gas as a means of power generation, and gives related information. 1400 w. Am Mach—Feb. 8, 1900. No. 32400.

Gas Works.

A de Brouwer Coke-Conveyor and a Carburetted Water-Gas Plant at the Crystal Palace Gas-Works. Illustrated description of these improvements. 5000 w. Jour Gas Lgt—Jan. 23, 1900. No. 32358 A.

"Kugel" Light.

The Illuminating Power and Color of the "Kugel" High-Pressure Gas Light. Dr. H. Bunte and Dr. P. Eitner, in the *Journal für Gasbeleuchtung*. An account of an exhaustive investigation of this high-pressure gas light, directed chiefly to the points named. 2700 w. Jour Gas Lgt—Jan. 30, 1900. No. 32459.

Photometry.

German Views of Gas Photometry. On gas testing in Germany, Austria and France, showing much diversity of methods, even among different cities of Germany. 1700 w. Jour Gas Lgt—Jan. 30, 1900. No. 32458 A.

Pintsch Gas.

The Oil Gas Plant at Hütteldorf, near Vienna (Die Oeglas-Anlage in Hütteldorf bei Wien). Franz Walter. Including a general discussion of the manufacture of illuminating gas from oil, and a fully illustrated description of this modern plant for producing and compressing the gas for use in train lighting. 4500 w. 1 plate. Oesterr Monatschr f d Oeffent Baudienst —Jan., 1900. No. 32650 D.

MARINE AND NAVAL ENGINEERING

Battleship.

United States Battleship Maine. A description of the new Maine. 2200 w. Marine Rev—Feb. 8, 1900. No. 32442.

Boilers.

Boilers for Big Ships. On the design of Babcock and Wilcox steam generators that are being installed in nine modern freighters of the Great Lakes, with reports of tests made by U. S. Navy Bureau of Steam Engineering. 1300 w. Marine Rev —Feb. 8, 1900. No. 32448.

Cargo Steamers.

The Distribution of Materials in the

Upper Works of Large Steamers. Samuel J. P. Thearle. Read before the North-East Coast Inst. of Engs. and Shipbuilders. Changes made necessary by the growing tendency to build very many large cargo steamers, and to place extensive superstructure upon them are discussed. Ill. 3800 w. Engr, Lond—Feb. 9, 1900. No. 32580 A.

Coaling Stations.

The United States Foreign Coaling Stations. Information from the recent report of Admiral Bradford, of the U. S. Navy, showing the importance of the coal trade and coaling stations in naval matters. 2000 w. Ir & Coal Trds Rev—Feb. 2, 1900. No. 32472 A.

Deutschland.

The Express Steamer "Deutschland" (Der Schnelldampfer "Deutschland"). A general description of the vessel, with views of the work of construction in progress, and of the engines erected in the works; also an account of the ceremonies of the launch. 1800 w. Stahl und Eisen —Jan. 15, 1900. No. 32640 D.

Disinfecting.

Disinfecting Ships. C. M. Green. On the development of the government work of disinfecting vessels, crew, passengers and baggage to prevent the spread of infectious diseases; describes the Sanator, a modern vessel for this work. Ill. 4500 w. Marine Rev—Feb. 15, 1900. No. 32537.

French Navy.

A New French Naval Scheme. Editorial comment on the programme of 1896, and on the programme to be soon submitted to Parliament. 1700 w. Engr, Lond—Feb. 9, 1900. No. 32577 A.

Ice Breakers.

Ice Breakers in Polar Exploration. Edwin Swift Balch. An account of the "Yermak" and her voyages, and the value of this means of penetrating the polar regions. 1000 w. Jour Fr Inst—Feb., 1900. No. 32414 D.

Ironclad.

The New Dutch Ironclad Koningin Regentes. Illustrations, with brief description. 500 w. Engr, Lond—Feb. 9, 1900. No. 32576 A.

Marine Congress.

International Marine Congress at Paris. The programme of the Congress to be held during the Exposition of 1900. 900 w. U. S. Cons Repts, No. 654—Feb. 14, 1900. No. 32464 D.

Mechanical Stokers.

Mechanical Stokers, S.S. Pennsylvania. Describes the principal features of this vessel, engaged in the carriage of freights on the Great Lakes, and gives illustrated description of the stokers, with report of tests. 3800 w. Engr, Lond—Jan. 26, 1900. No. 32377 A.

Naval Development.

Tendencies of Foreign Naval Development. George H. Peters. A review of foreign views and tendencies as represented in the press and other publications. 4500 w. Naut Gaz—Feb. 22, 1900. No. 32589.

Ore Carrying.

The Ore Carrying Fleet of 1900. Waldon Fawcett. Illustrates and describes the ships that will transport the 20,000,000 tons on the lakes. 1600 w. Am Mfr & Ir Wld—Feb. 1, 1900. No. 32296.

River Steamer.

Magnificent River Steamer. Illustrated description of the Tashmoo, a vessel similar to Hudson River boats, building at Detroit for service on St. Clair and Detroit rivers. 900 w. Marine Rev—Feb. 8, 1900. No. 32445.

Ship Building.

From Lakes to Seaboard. A view of conditions presented to ship builders of the Great Lakes and the Atlantic coast by the opening of Canada's St. Lawrence River canals, and the proposed New York State canal improvements. Ill. 1700 w. Marine Rev—Feb. 8, 1900. No. 32447.

Shipbuilding and Marine Engineering in 1899. Benjamin Taylor. A comprehensive review of the work of the past year, showing the remarkable mechanical achievements in one of the greatest of engineering industries. 4500 w. Engineering Magazine—March, 1900. No. 32686 B.

Ship Building Industry in America. Gives tabulated report of vessels under construction, and other information showing a prosperous condition. 1800 w. Marine Rev—Feb. 8, 1900. No. 32441.

Ships.

Ships and Their Makers. An illustrated account of the Clydebank shipyard and the vessels built there. 8000 w. Commerce—Feb. 7, 1900. No. 32590 A.

Shipyards.

Full Share of Prosperity. Summary of the year's work at the Newport News shipyard, with illustrations. 800 w. Marine Rev—Feb. 8, 1900. No. 32446.

Newest Practice in American Shipyard Appliances. Waldon Fawcett. On the recent development in the equipment of shipyards, calling attention to innovations adopted in various yards and reforms in methods. 2500 w. Ir Age—Feb. 22, 1900. No. 32713.

Where the New Maine is Building. Illustrated description of important improvements at the Philadelphia works of

Wm. Cramp & Sons Co. 2800 w. Marine Rev—Feb. 8, 1900. No. 32443.

Steamships.

Additions to Fleet of the Cunard Line —S.Ss. Saxonia and Iverina. Illustrated description of vessels for the Boston-Liverpool service. 600 w. Marine Engng—Feb., 1900. No. 32388 C.

Steering Gear.

See Electrical Engineering, Power.

Tenders.

New Light-House Tenders. Illustrated description of the Heather, to be built for Oregon coast service. 700 w. Marine Rev—Feb. 8, 1900. No. 32444.

Transport Service.

Work of the U. S. Army Transport Service at San Francisco, Cal. An illustrated account of difficulties met and conquered in the transportation of 40,000 troops across the Pacific to the Philippines. 1800 w. Marine Engng—Feb., 1900. No. 32387 C.

Warships.

The Modern Warship, as Combining in Itself the Highest Results of Skill, Ingenuity and Scientific Knowledge. George W. Melville. An address delivered on the occasion of the celebration of the seventy-fifth anniversary of the Franklin Inst. 6500 w. Jour Fr Inst—Feb., 1900. No. 32413 D.

Yachts.

American Builders of Steam Yachts. An illustrated article showing the rapid development of this branch of ship-building, that has extended to nearly all of the principal yards. 2000 w. Marine Rev—Feb. 22, 1900. No. 32724.

MECHANICAL ENGINEERING

AUTOMOBILISM.

Accumulators.

Competitive Tests of Accumulators in France. A. de Courcy. A brief account of tests made by the Automobile Club of France. Ill. 700 w. W Elect'n—Feb. 3, 1900. No. 32301.

The Storage Battery from the Standpoint of the User. W. M. Hutchinson. The writer's views of electrically propelled vehicles, after 18-months' personal experience, with a brief explanation of his method of keeping in order and caring for a vehicle battery. Ill. 2000 w. Horseless Age—Jan. 31, 1900. No. 32293.

English Vehicles.

English Electrical Vehicles. Brief illustrated description of the Electric Motive Power Company's dog-cart. 700 w. Ind & Ir—Jan. 26, 1900. No. 32362 A.

European Types.

European Types of Electric Automobiles. Illustrated descriptions of vehicles made by several of the more important manufacturers abroad. 1300 w. Elec Wld & Engr—Feb. 10, 1900. No. 32429.

Fore-Carriage.

Solignac's Electric Fore-Carriage. From *La Nature*. Illustrates and describes an apparatus recently presented to the Société des Voitures Électriques, of Paris. 600 w. Sci Am Sup—Feb. 24, 1900. No. 32599.

Gasoline Motors.

Gasoline Motors for Automobiles. George Kellogg Barrett. Outlines the features to be kept in mind in designing a gasoline engine for automobile use. 1800 w. Mod Mach—Feb., 1900. No. 32346.

Motive Power.

Compressed Air versus Steam for Motor Vehicles. Henry F. Bryant. Gives results of investigations which generally favor steam as a motive power. 3200 w. Horseless Age—Jan. 31, 1900. No. 32292.

Motor Trials.

The Motor Competition of the "Locomotion Automobile" (Le Concours de Moteurs de la "Locomotion Automobile"). Gaston Sencier. With details of the methods of testing, and tabulated data of the results; these relating to internal combustion motors of various kinds. Two articles, 6000 w. Revue Technique—Jan. 10, 25, 1900. No. 32605 each D.

Motor Vehicle.

The "Balmoral" Motor Char-a-Banc. Illustrated description of a conveyance carrying 16 persons, and fitted with a two-cylinder, horizontal, petroleum-spirit motor. 900 w. Ind & Ir—Feb. 9, 1900. No. 32574 A.

The "New Orleans" Motor-Voiturette. Brief illustrated description. 500 w. Ind & Ir—Feb. 2, 1900. No. 32478 A.

HYDRAULICS.

Pumping Engines.

See Mechanical Engineering, Steam Engineering.

Pumps.

Some Recent Improvements in Worthington Pumping Machinery. Edward C. R. Marks. From a paper read before the Birmingham Assn. of Mechanical Engs. Illustrated description of these improvements, with a statement of the advantages. 2000 w. Prac Engr—Feb. 9, 1900. No. 32593 A.

Speed Variations in Fly Wheel Pumps (Der Ungleichförmigkeitsgrad von Schwungradpumpen). F. Wimbersky. A graphical analysis of the action of the fly wheel in regulating the speed of single, double, and triple acting pumps. 1200 w. Zeitsch d Ver Deutscher Ing—Jan. 27, 1900. No. 32617 D.

MACHINE WORKS AND FOUNDRIES.

Bearings.

Some Causes of Excessive Heating in Bearing Metals. Robert Job. Showing the importance of the microscope in studying these alloys. Ill. 3000 w. Am Engr & R R Jour—Feb., 1900. No. 32270 C.

Blue-Printing.

An Interesting Example of a Modern Blue-Printing Room. Illustrates one of the most elaborate and expensive blueprinting rooms, recently built at the works of the Brown Hoisting and Conveying Machine Co., at Cleveland, O. 1000 w. Eng News—Feb. 22, 1900. No. 32710.

Brass.

The Brass Industry in the Naugatuck Valley. Reviews the present condition of this industry and the causes. 1400 w. Ir Age—Feb. 15, 1900. No. 32489.

Castings.

Casting a Six-Way Pipe Without a Pattern. Jas. A. Murphy. Illustrated directions for the work. 1000 w. Am Mach—Feb. 22, 1900. No. 32596.

The Casting of a Lathe Bed. R. H. Palmer. Illustrates and describes the casting of a lathe bed 27 feet long. 8000 w. Foundry—Feb., 1900. No. 32495.

The Manufacture of Steel Castings. J. E. Fletcher. From a paper read before the Manchester Assn. of Engs. Examines the design of castings used in machine construction, pointing out where the difficulties occur, and suggesting how to overcome them. Ill. 4000 w. Foundry —Feb., 1900. No. 32497.

Cast Iron.

See Mining and Metallurgy, Iron and Steel.

Crane Girder.

Calculations for a Crane Girder. A. D. Williams. Considers one particular girder, showing how the formulas met with in the "pocket books" were applied. 2000 w. Am Mach—Feb. 8, 1900. No. 32396.

Cranes.

Cantilever Cranes. Waldon Fawcett. Illustrated account showing the development and the great saving of time and money. Also notes the principal uses of these cranes. 2000 w. Sci Am—Feb. 10, 1900. No. 32403.

150-Ton Electric Crane at the Imperial Dock in Bremerhaven, Germany. Translated from the *Zeitschrift des Vereines Deutscher Ingenieure.* Illustrated detailed description of the largest crane in the world. 2700 w. Eng News—Feb. 8, 1900. No. 32411.

Overhead Cranes for Handling Material in Bulk (Hochbahnkrane zum Umladen und Aufstapeln von Massengütern). H. Ernst. Especially discussing the various forms of overhead conveyers for handling material in loading and unloading vessels, as extensively used in the United States. 4000 w. Zeitschr d Ver Deutscher Ing—Jan. 27, 1900. No. 32-618 D.

See Electrical Engineering, Power.

Crank Shafts.

Crank Shafts for Large Engines. W. H. Booth. A reply to criticisms of a former article, with an explanation of the writer's views. Ill. 1500 w. Am Mach —Feb. 15, 1900. No. 32492.

Cylinders.

Cylinders Under Internal Pressure. Alfred Petterson. Gives results of the writer's investigations, examining formulas. 1800 w. Am Mach—Feb. 15, 1900. No. 32493.

Design.

Notes on Machine Design (Betrachtungen über die Maschinen und den Maschinenbau). Ernst A. Brauer. An address before the technical high school at Karlsruhe, discussing the relation of the engineer and his education to his work, especially relating to the department of machine design. 5000 w. Zeitschr de Ver Deutscher Ing—Jan. 27, 1900. No. 32-616 D.

Forging Machine.

A Powerful Pneumatic Forging Machine. Illustrates and describes a machine used in the Burnside shops of the Ill. Cent. Ry., designed by Martin Kennedy. 900 w. Ry & Engng Rev—Feb. 24, 1900. No. 32740.

Foundry Iron.

Foundry Iron. Herbert Pilkington. Abstract of a paper read before the South Staffordshire Iron & Steel Inst. On the need of iron-founders, in England, becoming more familiar with the chemical constituents of their iron, and the behavior of iron of given analysis. 2500 w. Ir & Coal Trds Rev—Jan. 26, 1900. No. 32-370 A.

Flywheels.

Molding a Flywheel. R. H. Palmer. Illustrates and describes the work. 1600 w. Am Mach—Feb. 8, 1900. No. 32398.

Index Plate.

Originating an Index Plate. Illustrates

and describes the work as carried out at the Pope Mfg. Co.'s works. 1400 w. Am Mach—Feb. 1, 1900. No. 32279.

Iron Foundry.

The Walker & Pratt Foundry at Watertown, Mass. Illustrated detailed description of a very fine plant. 3000 w. Am Mach—Feb. 1, 1900. No. 32278.

Jigs.

Jigs for Drilling Sprocket Wheels. A. G. Miles. Sketches showing a pair of tandem sprockets and the two jigs for drilling the same, so that when the smaller one is mounted upon the larger one they shall revolve true together. Describes the operation. 700 w. Am Mach—Feb. 22, 1900. No. 32598.

Lathes.

Improved Bench Lathe. Illustrated description of the Cataract bench lathe. 700 w. Am Mach—Feb. 15, 1900. No. 32494.

Liquid Pressure.

Liquid Operated Machine Tools. H. A. Coombs. A review of patents showing what has been accomplished in this line. 2500 w. Am Mach—Feb. 1, 1900. No. 32281.

Lobed Wheels.

A New Method of Deriving Holditch's Interchangeable, Elliptical, Lobed Wheels, Together with a Simple Geometrical Demonstration of Their Rolling Properties. H. W. Rasche. Illustrated demonstration of method. 1400 w. Am Mach—Feb. 8, 1900. No. 32397.

Purchasing.

Functions and Organisation of the Purchasing Department. Hugo Diemer. A discussion of a very important factor in successful works management. 2000 w. Engineering Magazine—March, 1900. No. 32681 B.

Secretiveness.

The Policy of Secretiveness in Industrial Works. A. E. Outerbridge. A comparison of European and American practice in regard to exclusiveness in access to workshops, showing the gradual assimilation of the practice on both sides of the Atlantic. 3000 w. Engineering Magazine—March, 1900. No. 32684 B.

Shaper.

A Shaping Machine with Novel Features. Illustrated description. 700 w. Am Mach—Feb. 1, 1900. No. 32280.

The Stockbridge Shaper. Illustrated description of a new shaper having points of novelty and interest. 500 w. Am Mach—Feb. 22, 1900. No. 32595.

Shop Practice.

The Revolution in Machine Shop Practice. Henry Roland. Mr. Roland's concluding paper discusses the machine shop of the immediate future, showing the probable modifications which may result from the general introduction of automatic tools and repetitive methods. 2000 w. Engineering Magazine—March, 1900. No. 32687 B.

Shop Ventilation.

See Architectural Engineering, Heating and Ventilation.

Tinning.

Tinning Process for Iron Ware. Describes a tinning process for iron castings. 1300 w. Am Mach—Feb. 22, 1900. No. 32597.

Workshops.

The Ranelagh Works, Ipswich. Illustrated description of fine English shops and their equipment. 3500 w. Engng—Feb. 9, 1900. Serial. 1st part. No. 32583 A.

POWER AND TRANSMISSION.

Air Compressors.

The Speed of Air Compressors. Frank Richards. A discussion of the proper speed of an air compressor, written in reply to an inquiry. 1300 w. Am Mach—Feb. 8, 1900. No. 32395.

Bicycles.

The Running Gear of Bicycles (Die Bewegungs-mechanismen des Fahrrades). R. Frank. A general detailed discussion of the various portions of bicycle driving gear. The first portion is devoted to the theory and practice of ball-bearing construction. Serial. Part 1. 4500 w. Zeitschr d Ver Deutscher Ing—Jan. 27, 1900. No. 32615 D.

Clutch.

A Large Magnetic Clutch. Illustrated description of a magnetic clutch used to transmit 3000 h. p. in a St. Louis station. 600 w. Eng Rec—Feb. 3, 1900. No. 32320.

Elevators.

The Pneumatic Elevator Safety. J. J. Swann. Illustrates and describes an application of an air brake to elevators. 1500 w. Compressed Air—Feb., 1900. No. 32302.

Gears.

Gearing for the Reduction of Angular Velocity. From *La Nature*. Particulars and illustrations of the Humpage Epicycloidal angular velocity reducer with progressive gearing. 1100 w. Sci Am Sup—Feb. 17, 1900. No. 32506.

Some Things Seen at the Works of the Fellows Gear Shaper Company—New Features of the Gear Shaper. Illustrated description of interesting tools. 1600 w. Am Mach—Feb. 15, 1900. No. 32491.

The Fellows Spur-Bevel Gear. Illustrated detailed description of a curious

gear. 1100 w. Am Mach—Feb. 22, 1900. No. 32594.

SPECIAL MOTORS.

Gas Engines.

Gas and Oil Engines. A discussion of engines of this class, explaining fundamental principles, design and operation. Ill. 1700 w. Power—Feb., 1900. Serial, 1st part. No. 32263.

Gas Engine Guarantees Technically Considered. William T. Magruder. Abstract of a paper read before the National Assn. of Gas and Gasoline Engine Mfrs. Considers power ratings, regulation, cost of running and fuel consumption. 2800 w. Am Mach—Feb. 8, 1900. No. 32399.

Gas Engine Plant in Lake Michigan. Brief illustrated description of the new intake crib located six miles from Chicago, its construction, and the electric-lighting equipment. 1200 w. Mod Mach—Feb., 1900. No. 32345.

The Future of Electrical Supply. Alton D. Adams. A discussion of the advantages of the gas engine as a motive power for electrical generating stations, and of the economy of gas as a means of transmitting power. 3000 w. Engineering Magazine—March, 1900. No. 32682 B.

Gasoline Motors.

See Mechanical Engineering, Automobilism.

Gas Power.

Gas Engine Driving for Electric Plants (Elektrizitätswerke mit Gasmachinenbetrieb). M. Krone. A critical comparison of the cost of operating generating stations by gas engines using producer gas, with steam engines and boilers, showing the economy of the former method. A description of the Clausthal plant is given. 6000 w. Zeitschr d Ver Deutscher Ing—Jan. 13, 1900. No. 32612 D.

STEAM ENGINEERING.

Boilers.

Engine Room Practice. E. P. Gould. Special reference is made to the care of boilers. 1800 w. Marine Rev—Feb. 8, 1900. No. 32450.

See Marine Engineering.

Chimney.

A Chimney at the Paris Exposition. Illustrated description of a highly ornamental stack 289 feet high and from 15 to 20 feet in diameter inside. 1300 w. Eng Rec—Feb. 17, 1900. No. 32530.

Efficiency.

Increasing the Efficiency of Steam Engines. Description of experiments by Prof. E. Josse of Germany with a process for utilizing the heat of exhaust steam for evaporating another liquid having a lower boiling point than water. Ill. 1500 w. U. S. Cons Repts, No. 663—Feb. 26, 1900. No. 32733 D.

Engine Testing.

A Pumping Engine Test. An account of the second test made by W. F. M. Goss of the 20,000,000-gal. triple-expansion pumping engine built for the Indianapolis Water Co. Gives a summary of the engine's dimensions and of facts derived from the test. 1700 w. R R Gaz—Feb. 23, 1900. No. 32703.

Engine Tests. George A. Barrus. Describes methods of measuring feed water, indicating, and the general scheme of a feed-water test. 4200 w. Eng Rec—Feb. 17, 1900. Serial. 1st part. No. 32528.

Furnaces.

The Computation of Furnaces (Die Berechnung der Feuerungen). Ed. Brauss. A discussion of the best proportions for furnaces, flues, and chimneys for steam boilers, in order to obtain perfect combustion and absence of smoke production. 3000 w. Gesundheits-Ingeneiur—Jan. 31, 1900. No. 32636 B.

Mechanical Stokers.

See Marine and Naval Engineering.

Multiple Expansion.

A Study of the Action of Multiple Expansion engines (Etude du Fonctionnement des Moteurs à Plusieurs Cylindres). M. E. Lefer. A general examination of the action of steam in several cylinders, with the aid of theoretical diagrams. Numerous examples are worked out for various cylinder ratios. 20,000 w. Bull de la Soc d'Encour—Jan. 31, 1900. No. 32610 G.

Drop in Multiple Expansion Engines. Editorial discussion of a paper by B. L. Weighton, read before the North-East Coast Inst. of Engs. and Shipbuilders. 2200 w. Engr, Lond—Jan. 26, 1900. No. 32376 A.

Pumping Engines.

Pumping Engine at a Westphalian Colliery. Bergassessor von Sobbe. From *Zeitschrift für Berg-Hutten-und Salinenwesen.* Illustrated description of engines used in recovering the Royal Ibbenbüren Colliery. 1200 w. Col Guard—Feb. 9, 1900. No. 32581 A.

Trials of Two Pumping Engines. Report of two trials made by Prof. Wm. Cawthorne Unwin of a pair of triple-expansion vertical pumping engines supplied to the Leeds water-works. 5000 w. Engr, Lond—Feb. 9, 1900. No. 32579 A.

Steam.

The Quality of Steam. Editorial discussion of means to secure the purity of steam, and dry steam. 1700 w. Engr, Lond—Feb. 9, 1900. No. 32578 A.

Steam Engine.

A Giant Steam Engine at the Exposi-

tion (Une Machine à Vapeur Géante à l'Exposition). A. Mahoudeau. An illustrated description of the 2500 h. p. triple-expansion engine to be exhibited by Borsig, of Berlin, driving the Siemens & Halske electric generators. 1200 w. Revue Technique—Jan. 25, 1900. No. 32607 D.

Superheating.

The Advantages of Superheating and the Superheater of the University of Liege. Georges Duchesne. Considers the advantages and inconveniences of superheating and describes the superheater at Liege, giving some results obtained. 1700 w. Am Elect'n—Feb., 1900. No. 32288.

Switzerland.

Steam Engine Building in Switzerland. A. Stodola. An interesting account of the remarkable development of engine building under seemingly adverse conditions, with numerous illustrations of the products of the leading builders of Switzerland. 4000 w. Engineering Magazine—March, 1900. No. 32683 B.

Valve Gear.

New Valve Gear for Steam Engines. Illustrated description of the Lang valve gear, which is reported as giving satisfactory results on marine and stationary engines to which it has been applied. 1200 w. Eng News—Feb. 15, 1900. No. 32520.

MISCELLANY.

Education.

Evolution of Technical Education in Economics, Politics, Statecraft and Morals. Robert H. Thurston. An address at the meeting commemorating the seventy-fifth anniversary of the Franklin Inst. 14000 w. Jour Fr Inst—Feb., 1900. No. 32412 D.

Guns.

Our Guns and Their Uses in War. A discussion of British guns and their fittings. 3000 w. Engr, Lond—Feb. 2, 1900. No. 32465 A.

Vickers' Automatic 14-Pounder Gun. Illustrated description of a gun built for the United States Government. 1100 w. Engng—Feb. 9, 1900. No. 32584 A.

Indexing.

A Decimal Index to Mechanical Engineering Literature. Describes the system of the Dept. of Mech. Engs., Univ. of Illinois. 2000 w. Eng Rec—Feb. 17, 1900. No. 32532.

Iron Barrels.

How May Iron Barrels Be Satisfactorily Constructed to Avoid Accidents? (Wie Werden Zweckmässig Schmiedeiserne Transportfässer Hergestellt um Unfälle zu Verhüten?) H. Claussen. Showing that the use of electric welding for the joints of wrought iron barrels does not offer a sufficient strength, unless reinforced by riveting. 1800 w. Glaser's Annalen—Jan. 15, 1900. No. 32644 D.

Liquid Air.

The Technical Applications of Liquid Air (Ueber die Anwendbarkeit Flüssiger Luft in der Technik). Carl Linde. A discussion of the various possible uses of liquid air, as a source of power, as an explosive, as a means of producing oxygen, etc., etc. 2500 w. Zeitschr d Ver Deutscher Ing—Jan. 20, 1900. No. 32613 D.

Machine Labor.

Hand and Machine Labor. The first of a series of articles based on the report of the Commissioner of Labor of the United States, concerning the effect of the use of machinery upon labor and cost of production, on wages, etc. 2700 w. Engng—Jan. 26, 1900. Serial. 1st part. No. 32378 A.

Manometer.

Differential Manometer with Photographic Registering Device (Ueber Differential-Manometer mit Photographischer Registrier-Vorrichtung). Paul Fuchs. Illustrated description of a photographic registering device, adapted for use with pressure gauges, thermostats, gas compositeters, etc. 2500 w. 1 plate. Gesundheits Ingenieur—Jan. 15, 1900. No. 32635 B.

Pneumatics.

Pneumatic Engineering. Editorial review of the various applications of compressed air. 1600 w. Engng—Feb. 9, 1900. No. 32586 A.

The Law of Resistance of the Air to the Motion of Projectiles (Sur la Loi de la Résistance de l'Air au Mouvement des Projectiles). Paul Vielle. A discussion of the wave formations in the air accompanying the flight of projectiles; with tables of pressures, velocities and temperatures. 1500 w. Comptes Rendus—Jan. 29, 1900. No. 32631 D.

Refrigeration.

Brewery Refrigeration. E. Brueckner. Illustrated description of the refrigerating plant in R. Leicht's brewery at Vaihingen, Germany. 1200 w. Ice & Refrig—Feb., 1900. No. 32321 C.

Chloride of Calcium in Refrigeration. Madison Cooper. On its value as an absorbent and purifier for cold storage rooms. Ill. 3400 w. Ice & Refrig—Feb., 1900. No. 32322 C.

Thermodynamics.

Thermal Lines on the Isometric Planes. Lays down the common "thermal lines" of thermodynamic graphics in such a manner that they may all be exhibited at once and their peculiar characteristics compared. Ill. 1100 w. Sib Jour of Engng—Feb., 1900. No. 32556 C.

MINING AND METALLURGY

COAL AND COKE.

Analysis.

Coal Analysis. A review of the final report of the Committee of the American Chemical Society on Coal Analysis, giving a description of all their recommendations which differ from the usual practice. 2200 w. Eng Rec—Feb. 10, 1900. No. 32424.

Coaldust.

The Ignition of Coaldust by Electricity. Sydney F. Walker. Discusses the possibility of an arc lamp, or a glowing wire, igniting an atmosphere of coaldust, and the safety of electrical supply in coal mines. 2000 w. Col Guard—Jan. 26, 1900. No. 32365 A.

Coal Working.

Working by Panels and Intermediate Stages of Three Stopes at the Commentry Colliery. M. Martinet. From a communication to the Société de l'Industrie Minerale. Illustrated description of the system named. 3000 w. Col Guard —Feb. 2, 1900. No. 32476 A.

Coke.

Relation of Coke Producers to Consumers. E. M. Peters. Read before the Cent. Min. Inst. of W. Penn. The importance of the industry is considered and how to produce what the consumer requires. 2000 w. Mines & Min—Feb., 1900. No. 32342 C.

Coke Plant.

The Semet Solvay Coke Plant at Dunbar, Pa. William L. Affelder. Illustrated description of the coke ovens and the apparatus for the recovery of the by-products. 2200 w. Mines & Min—Feb., 1900. No. 32336 C.

Connellsville.

The Connellsville Coking Region. F. C. Keighley. Read before the Cent. Min. Inst. of W. Penn. A history of the development and an account of the wonderful production. 4500 w. Mines & Min—Feb., 1900. No. 32341 C.

Deep Beds.

A New Method for Working Deep Coal Beds. H. M. Chance. Describes a new system, illustrating by plate, and gives suggestions for its operation. 2000 w. Trans Am Inst of Min Engs—Feb., 1900. No. 32547 D.

Eureka Mines.

The Largest Collieries in the United States. Burcham Harding. Illustrated account of the Eureka Mines, near the center of Pennsylvania. 1400 w. Eng & Min Jour—Feb. 17, 1900. Serial. 1st part. No. 32539.

Fiery Mines.

Methods of Working in Fiery Brown-Coal Seams. H. Winklehner. From *Allegemeine bergmännische Zeitschrift.* Illustrates and describes special methods of working introduced in a mine in Hungary. 2000 w. Col Guard—Jan. 26, 1900. No. 32366 A.

France.

The Coal Basin of Gard and the Phenomena of Drift (Le Bassin Houiller du Gard et les Phénomènes de Charriage). Marcel Bertrand. A study of the geology of this important coal basin of Southern France, showing the causes of some hitherto unexplained peculiarities. 3000 w. Comptes Rendus—Jan. 29, 1900. No. 32630 D.

Headframes.

Steel Headframes. Illustrated description of recent examples erected in the Wyoming and Lackawanna coal basins of Pennsylvania. 3500 w. Mines & Min—Feb., 1900. No. 32335 C.

Indian Coal.

The Coking Quality of Indian Coal. From a report by R. H. Mahon on experiments made to test the coking quality. 4500 w. Col Guard—Feb. 2, 1900. No. 32474 A.

Pillars.

Pillar Drawing. Jas. B. Davis. Illustrated description of the method used for taking out pillars when the workings have been flushed with culm. 1000 w. Mines & Min—Feb., 1900. No. 32333 C.

Report.

The Report of the Rhenish Westphalian Coal Syndicate for the Year 1899 (Vorstandsbericht des Rheinisch-Westfälischen Kohlensyndikats über das Jahr 1899). Giving tabulated results of the year's operations, showing the increased output over the preceding year. 2000 w. Glückauf—Feb. 3, 1900. No. 32672 B.

West Virginia.

The Kelly's Creek Coal Mines, West Virginia. Edward H. Coxe. Describes the mines and manner of working. 1100 w. Eng & Min Jour—Feb. 10, 1900. No. 32438.

Winding.

Winding Drum with Tangential Arms at the Blanzy Colliery. Paul Perroy. From a communication to the Société de l'Industrie Minérale, Saint Etienne. Illustrated description of a new type of winding drum suggested by a bicycle wheel. 2700 w. Col Guard—Jan. 26, 1900. No. 32364 A.

COPPER.

Australia.

South Australian Copper Mines. Report of mines by the inspector, W. H. Matthews. 2500 w. Aust Min Stand—Jan. 11, 1900. No. 32499 B.

New Jersey.

The Schuyler Copper Mines, New Jersey. An illustrated account of one of the oldest copper mines in the United States. 1300 w. Eng & Min Jour—Feb. 3, 1900. No. 32347.

North Carolina.

The Union Copper Mines, Gold Hill, N. C. Dr. A. R. Ledoux. An account of this property, worked first for the gold, but long ago abandoned; recently reopened. Its fine plant is illustrated and described. The ores carry gold and silver in small quantities with the copper. 3300 w. Eng & Min Jour—Feb. 10, 1900. No. 32439.

Review.

The Copper Market and Copper Mining Finance in 1899. John B. C. Kershaw. A review of the year and the causes of anxiety to those interested in copper production. 1500 w. Elec Rev, Lond—Feb. 2, 1900. No. 32457 A.

Supply.

The World's Supply of Copper. Frederick H. Hatch. A very comprehensive review of the output and consumption, with numerous tables and statistics, and illustrated descriptions of important mines and smelting works. 5000 w. Engineering Magazine—March, 1900. No. No. 32685 B.

United States.

Copper Resources of the United States. Henderson Gilbert. A review of the mines and their output. 1600 w. Yale Sci M—Feb., 1900. No. 32391 C.

GOLD AND SILVER.

Amalgamation.

Note on the Plate-Amalgamation of Gold and Silver. E. A. H. Tays. Data regarding plates from four battery-aprons. 500 w. Trans Am Inst of Min Engs—Feb., 1900. No. 32544 D.

Aurex Sluice.

Notes on the Aurex Sluice. T. M. Chatard and Cabell Whitehead. Describes this apparatus for utilizing the electric current in connection with cyanide solutions upon gold and its ores, giving the results obtained in test-runs, and the conclusions reached. 3400 w. Eng & Min Jour—Feb. 3, 1900. No. 32348.

Black Hills.

Gold Ores of the Black Hills, South Dakota. H. M. Chance. Describes the silicious gold-belt, the reduction works, and gives an account of the principal Black Hills gold-mining companies. 3000 w. Trans Am Inst of Min Engs—Feb., 1900. No. 32552 D.

British Columbia.

The Auriferous Alluvium of the Fraser River and Its Tributaries. J. D. Kendall. Part first gives an outline of the economic history and some hydrographic data. 2000 w. B. C. Min Rec—Feb., 1900. Serial. 1st part. No. 32484 C.

California.

Gold Bearing Lodes of the Sierra Costa Mountains in California. O. H. Hershey. Describes the general geology of this region and the mining districts, discussing the probability of the deposits proving valuable. 7700 w. Am Geol—Feb., 1900. No. 32490 D.

Cape Nome.

The New Mining District at Cape Nome. Enos Brown. Information concerning this region, its location, climate, deposits, etc. 900 w. Sci Am—Feb. 3, 1900. No. 32265.

Chlorination.

The Chlorination of Gold-Ores. F. C. Smith. Gives briefly the history and chemistry of the process, its operation and the difficulties. 3300 w. N. Z. Mines Rec—Nov. 16, 1899. No. 32259 B.

Cœur d'Alene.

Cœur d'Alene Mining Region. Arthur Lakes. Illustrates and describes the peculiarities of the country and gives an account of some of the larger mines. 2000 w. Mines and Min—Feb., 1900. No. 32-339 C.

Crushers.

The Bryan Mill as a Crusher and Amalgamator as Compared with the Stamp-Battery. E. A. H. Tays. Experience of the writer with the "Bryan roller quartz mill." 1800 w. Trans Am Inst of Min Engs—Sept., 1899. No. 32-546 D.

Distribution.

The Occurrence of Gold. W. H. Storms. Shows the wide distribution of gold and the need of careful study even where indications are absent. 1200 w. Min & Sci Pr—Feb. 10, 1900. No. 32502.

Dredging.

Dredging for Gold. Theo. F. Van Wagenen. Considers the problem of gold recovery by dredging, the conditions, etc. Ill. 2000 w. Min & Sci Pr—Jan. 27, 1900. Serial, 1st part. No. 32261.

Dredging: Its Present and Future Outlook. J. G. Hyde. On the chief difficulties yet to be overcome in gold-dredging.

1000 w. N. Z. Mines Rec—Nov. 16, 1899. No. 32256 B.

The Waiau River as a Gold-Dredging Channel. Ro. Carrick. A description of the dredging-ground. 1500 w. N Z Mines Rec—Nov. 16, 1899. No. 32257 B.

Georgia.

Gold Mining and Milling in Georgia. H. V. Croll. A brief illustrated description of past methods and remarks on recent advances. 2000 w. Min & Sci Pr—Feb. 3, 1900. No. 32402.

Gold Mine.

How to Open Up a Gold Mine. S. A. Josephi. Considers the necessary work, how it should be done, and particulars in regard to the probable cost. 1400 w. Mines & Min—Feb., 1900. No. 32334 C.

Kootenay.

In the Kootenay, B. C., District. Notes on Rossland Camp, Nelson, Slocan and Boundary districts. 2000 w. Can Min Rev—Jan. 31, 1900. No. 32297 B.

Mexico.

The Gold Zone of Copalquin, Durango, Mexico. Frank B. Fowler. An illustrated account of the San Fernando mines is given in part first. 2100 w. Eng & Min Jour—Feb. 24, 1900. Serial. 1st part. No. 32723.

Nova Scotia.

What Has Become of the Gold Run in the Tailings? B. C. Wilson. Read before the Min. Soc. of Nova Scotia. On the doubtful value of old tailings. 1300 w. Can Min Rev—Jan. 31, 1900. No. 32298 B.

Quartz Mine.

The O. P. Q. Quartz Mine, Waipori, Otago. An account of its development, with description of the working plant. 1300 w. N Z Mines Rec—Nov. 16, 1899. No. 32258 B.

Rhodesia.

Gold Mining Prospects in Rhodesia. R. R. Mabson. A very complete account of the ancient workings, existing mines and conditions of present production, with many characteristic illustrations. 4000 w. Engineering Magazine—March, 1900. No. 32680 B.

Silver King.

Geological Elements of the Silver King Basin. W. H. Lampker. Describes an interesting geological formation of great economic importance in Arizona. 1700 w. Min Rept—Feb. 1, 1900. No. 32383.

Utah.

Silver-Bearing Sandstones of Southern Utah. Don Maguire. A description of one of the few localities where silver is found in a sandstone formation. 2700 w. Mines & Min—Feb., 1900. No. 32343 C.

IRON AND STEEL.

Basic Steel.

The Talbot Continuous Open Hearth Steel Process. Describes the plant at the Pencoyd Iron Works, the process, the operation, results, etc. 4000 w. Ir Age—Feb. 8, 1900. No. 32401.

The Talbot Steel Process at the Pencoyd Iron Works. Explains a continuous basic open-hearth process conducted in an 80-ton tilting furnace. 1000 w. Eng Rec—Feb. 17, 1900. No. 32526.

Bessemer.

Small Bessemer Plants for Steel Castings (Die Klein-Bessemerei für Stahlformguss und Temperguss). Carl Rott. A description of the use of small Bessemer converters, of less than 1000 pounds capacity, for use in making steel castings for general purposes. Details of operation are given, and the increasing use of such furnaces predicted. 3500 w. Zeitschr d Ver Deutscher Ing—Feb. 3, 1900. No. 32621 D.

British Columbia.

Discoveries of Bessemer Steel Ore and the Sources of the Placer Gold of the Fraser River. K. Ludloff. Letter to the editor giving an account of the discoveries made by the writer. 1600 w. B. C. Min Rec—Feb., 1900. No. 32485 C.

Cast Iron.

Cast Iron. W. R. Lethaby. Lecture before the Arch't Assn., London, with discussion. Suggestions as to the uses and treatment. 9000 w. Builder—Feb. 3, 1900. No. 32461 A.

Formation-Temperatures.

The Temperatures at Which Certain Ferrous and Calcic Silicates are Formed in Fusion, and the Effect upon These Temperatures of the Presence of Certain Metallic Oxides. H. O. Hofman. Describes investigations made to obtain accurate details on this subject. 8800 w. Trans Am Inst of Min Engs—Sept., 1899. No. 32549 D.

Iron Mining.

Readjustment of Iron Mining Costs. William Kelly. Synopsis of the presidential address before the Lake Superior Min. Inst. 3000 w. Ir Trade Rev—Feb. 15, 1900. No. 32501.

Japan.

The Japanese Imperial Steel Works. Emile Schrödter. Translated from *Stahl und Eisen*. An illustrated description of these works, and general remarks concerning the industry. 2500 w. Ir & Coal Trds Rev—Feb. 2, 1900. No. 32471 A.

Manufacture.

The Manufacture of Iron and Steel. William Kent. Reviews the history of iron manufacture, and traces some of the

stages of development during the last two centuries. 3000 w. Sibley Jour of Engng—Feb., 1900. No. 32555 C.

Nickel Steel.

The Properties and Possible Uses of Nickel Steel. Editorial on the limited production of nickel and its impossibility of increase unless there is a discovery of nickel ore; with review of paper by David H. Browne, presented at the Inst. of Min. Engs.' meeting. 4000 w. Eng News—Feb. 15, 1900. No. 32518.

Pig-Iron.

A Peculiar Siliceous Efflorescence upon Pig Iron. B. F. Fackenthal, Jr. Descriptions and analyses of an efflorescence that appeared when the pigs were broken hot from the sow. 1500 w. Trans Am Inst of Min Engs—Feb., 1900. No. 32551 D.

Casting Pig Iron by Machinery. Illustrated description of machines built for the Cambria Steel Co., of Johnstown, Pa. 1000 w. Sci Am—Feb. 24, 1900. No. 32702.

Comments on Pig Iron Selling. George H. Hull. Read at Am. Foundrymen's Assn. Discusses the Syndicate System of Germany, the Warrant System of Great Britain, and selling methods in the United States. 4400 w. Am Mfr & Ir Wld—Feb. 8, 1900. No. 32440.

The Fracture of Pig Iron. Edward Kirk. Concerning some points of grading by this method. Considers the characteristics indicated as accurately as by chemical analysis, but only when judged by experts. 2000 w. Ir Trd Rev—Feb. 15, 1900. No. 32500.

Rail Steel.

Rail Steel—Its Chemistry and Heat Treatment. William R. Webster. A contribution to the problem of the relations between the chemical constitution and physical properties of steel. 3200 w. R R Gaz—Feb. 16, 1900. No. 32512.

Sampling.

A Device for Sampling Pig-Iron. Porter W. Shimer. Illustrated description. 400 w. Trans Am Inst of Min Engs—Feb., 1900. No. 32554 D.

Slags.

A Rapid Method of Determining Lime in Blast Furnace Slags. Titus Ulke. Describes a method recommended to smelter chemists, on account of the rapidity with which accurate lime determinations can be made by it. 300 w. Eng & Min Jour—Feb. 10, 1900. No. 32436.

Solution Theory.

Notes on the Solution Theory for Iron and Steel (Beiträge zur Lösungstheorie von Eisen und Stahl). Hanns Freiherr von Jüptner. A very full discussion by this eminent authority, of the theory of the solution of carbon in iron; with diagrams and curves, plotted from the researches of the author and of Eggertz and Howe. Four articles, 1 plate. Oesterr Zeitschr f Berg u Hüttenwesen—Jan. 13, 20, 27, Feb. 3, 1900. No. 32673 each B.

Steel.

Our Steel Industry. Charles H. Cramp. The wonderful development and the relation to ship building. 4500 w. Marine Rev—Feb. 1, 1900. No. 32282.

Wire Mills.

American Wire Rod Rolling. Abstract of a paper by M. Baackes, read before the Verein Deutscher Eisenhuettenleute, on the Development of the Wire Rod Mill, with special reference to the United States. Ill. 4500 w. Ir Age—Feb. 15, 1900. No. 32488.

The Development of Wire Rolling Mills, with Especial Reference to the United States (Die Entwicklung des Drahtwalzwerkes mit Besonderer Berücksichtigung von Nordamerika). M. Baackes. A paper before the *Verein Deutscher Eisenhüttenleute* giving a very full description of the American wire-rod rolling mills, with discussion. 10,000 w. Stahl und Eisen—Jan. 15, 1900. No. 32639 D.

MINING.

Accounts.

Mine Accounts. A. J. Yungbluth. On the arrangement of mine accounts for the cost sheet. 5600 w. Can Min Rev—Jan. 31, 1900. No. 32299 B.

Bolivia.

Some of the Undeveloped Resources of Bolivia. Sir Martin Conway. Interesting description of the country and its products, containing information of the mineral wealth. Map, and discussion. 7000 w. Jour Soc of Arts—Feb. 2, 1900. No. 32455 A.

British Columbia.

Mineral Resources Around Kamloops. W. M. Brewer. Describes the topography and character of the country, and some of the mining properties. Gives illustrations of the Python mine. 1400 w. Eng & Min Jour—Feb. 10, 1900. No. 32437.

Dam.

The Construction of a Concrete Dam in the 18 Heading of the Lillschächt Mine at Pribram (Ueber den Bau eines Betondammes am 18 Laufes des Lillschächter-Ostschlages in Pribram). W. Oppe. Describing the construction of an arched dam filled with concrete, to hold back the water in an important mine in Bohemia. 2000 w. 1 plate. Oesterr Zeitschr f Berg u Hüttenwesen—Jan. 20, 1900. No. 32674 B.

Disasters.

Notable Disasters in Foreign Mines (Bemerkenswerthe Unfälle beim Bergwerksbetriebe un Auslande). A tabulated list of mining disasters in other countries than Austria-Hungary, from 1895 to 1899 inclusive. 3000 w. Oesterr Zeitschr f Berg u Hüttenwesen—Jan. 27, 1900. No. 32675 B.

Explosion.

The Fire Damp Explosion at the Heinrich Shaft at Ostrawa, Moravia (Die Schlagwetter-Explosion am Heinrich Schachte in Mähr.-Ostrau). J. Mayer. A detailed account of the disaster, together with a description of the experiments made upon safety lamps. Serial. Part I. 2500 w. 1 plate. Oesterr Zeitschr f Berg u Hüttenwesen—Feb. 3, 1900. No. 32676 B.

Explosives.

Blasting with High Explosives. Harold Bouser. Deals with the methods of igniting, the coal shots, choice of explosives, etc. Ill. 3400 w. Ir & Coal Trds Rev—Jan. 26, 1900. No. 32369 A.

Dynamite Magazines at Slight Depths. From a report by the French Explosive Substances Commission on the Blanzy experiments, published in the *Annales des Mines*. Describes the experiments, giving results and conclusions. Ill. 3700 w. Col Guard—Feb. 9, 1900. No. 32582 A.

Methods of Priming and Firing Mine Shots. From a communication by Victor Watteyne and Lucien Denoël. Notes various solutions of the problem, but concludes that electric firing is the method most to be recommended. 1200 w. Col Guard—Jan. 26, 1900. No. 32368 A.

Haulage.

Endless Rope Haulage at the Coke Ovens of the Rochling Works. Herr Weihe. Translated from *Glückauf*. Illustrates and describes the arrangement of the haulage plane. 2200 w. Ir & Coal Trds Rev—Feb. 9, 19000. No. 32571 A.

Hoisting Engines.

The Operation and Economy of Compound Hoisting Engines (Ueber Compound Fördermaschinen, deren Betriebs und Dampfkonsumverhältnisse). A general discussion of the applicability of compound engines for winding mine-hoists, giving data and results of tests of a number of engines in service. 4000 w. Glückauf—Jan. 27, 1900. No. 32671 B.

Mine Locomotives.

Benzine Locomotive for Mine Haulage. E. Braun, in the *Zeitschrift für das Berg Hutten und Salinen Wesen*. Illustrates and describes the engine of the Deutz Gas Engine Co., giving facts relating to its economy and power. 4000 w. Ir & Coal Trds Rev—Feb. 9, 1900. No. 32572 A.

The Use and Abuse of Colliery Locomotives. W. W. Clayton. Read before the Chesterfield and Midland Counties Soc. of Engs. A brief account of the first locomotive used in a colliery, in 1811, with suggestions concerning care and operation. 2800 w. Can Min Rev—Jan. 31, 1900. No. 32300 B.

Mine Surveying.

The Real Error of a Survey. Joseph Barrell. Notes on the accuracy of surveys in inclined seams and an analysis of the sources of error. 2500 w. Mines & Min—Feb., 1900. No. 32337 C.

Pumping Engines.

See Mechanical Engineering, Steam Engineering.

Safety Lamps.

Experiments with Safety Lamps. Bergrath Meyer, in *Oesterreischische Zeitschrift für Berg und Huttenwesen*. Investigations as to the cause of an explosion led to the interesting experiments described. 1000 w. Col Guard—Feb. 2, 1900. No. 32475 A.

Stoping.

Stoping with Machine Drills. B. L. Thane. An account of what was accomplished with a "Baby Ingersoll" drill in the Chief Mine, at Sundrum, Alaska. 2400 w. Trans Am Inst of Min Engs—Sept,. 1899. No. 32550 D.

Transvaal.

The Electric Power and Lighting Plant at the Transvaal Gold Mining Estates, Limited, at Pilgrim's Rest (Die Elektrische Kraft und Lichtanlage der Transvaal Gold Mining Estates, Limited, in Pilgrimsrest). F. Klonne. A fully illustrated account of this plant, one of the best among the Transvaal mines. 2000 w. 1 plate. Glückauf—Jan. 20, 1900. No. 32670 B.

MISCELLANY.

Address.

The Characteristics and Conditions of the Technical Progress of the Nineteenth Century. James Douglas. Presidential address reviewing the changes that have affected the industrial growth of the United States. 7300 w. Trans Am Inst of Min Engs—Sept., 1899. No. 32553 D.

Aluminum.

The Latent Heat of Aluminum. E. Grafstrom. Brief illustrated account of experiments made by the writer. 600 w. R R Gaz—Feb. 23, 1900. No. 32705.

Brass.

See Mechanical Engineering, Machine Works.

Exposition.

The Industrial and Trade Exposition at Düsseldorf in 1902 (Die Industrie und Gewerbe Ausstellung in Düsseldorf in Jahre 1902). A short announcement concerning this forthcoming exposition, with especial relation to the department of mining and metallurgy, giving a view of the proposed mining building. 1500 w. 1 plate. Glückauf—Jan. 20, 1900. No. 32669 B.

Manganese.

The Manganese Deposits of Bahia and Minas, Brazil. John C. Branner. An account of these deposits, and illustrated description of the mines and method of ore cleaning. 3500 w. Trans Am Inst of Min Engs—Sept., 1899. No. 32548 D.

Metallography.

A View of the Present Status of Metallography (Ueberblick über den Gegenwärtigen Stand der Metallographie). E. Heyn. A discussion of the microscopic study of etched sections of metals and alloys, showing the progress which has been made in the study of materials by this method. Serial. Part 1. 6000 w. 1 plate. Zeitschr d Ver Deutscher Ing—Feb. 3, 1900. No. 32620 D.

Petroleum.

Petroleum in California. W. L. Watts. Address delivered at Los Angeles, Cal. Reviews the history of this mineral product in the state, describing the oil-fields. 2400 w. Trans Am Inst of Min Engs—Oct. 1899. No. 32545 D.

Petroleum in Europe (Le Pétrole en Europe). H. Neuberger and H. Noalhat. With especial reference to the wells in Central Galicia, in which American methods of working have been introduced. 4000 w. Revue Technique—Jan. 10, 1900. No. 32606 D.

The Development of the Petroleum Industry in the Caucasus (Développement des Enterprises de Pétrole au Caucase). A review of the commercial side of the subject, with data about the various companies engaged in the industry. 1800 w. Moniteur Industriel—Feb. 3, 1900. No. 32677 E.

Zinc and Lead.

Zinc and Lead Mines of Missouri and Kansas. Horace J. Stevens. An account of these mines, their production and future prospects. 2600 w. Mines & Min—Feb., 1900. No. 32340 C.

RAILWAY AFFAIRS

CONDUCTING TRANSPORTATION.

Accidents.

Rolling Stock in the United States. From advance sheets of the report of the Interstate Commerce Commission reviewing the causes of accidents to employees. 1400 w. R R Car Jour—Feb., 1900. No. 32433.

Train Accidents in the United States in December. Detailed list and classified summary. 5000 w. R R Gaz—Feb. 2, 1900. No. 32295.

Train Accidents in 1899. Editorial review with tables of statistics. 1500 w. R R Gaz—Feb. 23, 1900. No. 32706.

Car Movements.

The Graphic Block System of Recording Car Movements. Illustrated description of the system developed by G. H. McNamara for keeping a record of the movements and location of freight cars. It consists in using a separate card for each car, the cards being arranged in special filing cases. 2000 w. Eng News—Feb. 8, 1900. No. 32407.

Employees.

The Systematic Selection of Employees. R. C. Richards. Considers the importance of having good employees, and suggests a plan. 1400 w. Ry Age—Feb. 23, 1900. No. 32730.

Haulage.

Waste Haulage. Editorial giving an account of locomotive performance on the Soudan & South-Western Ry., and discussing economy in haulage. 2000 w. Engr, Lond—Feb. 2, 1900. No. 32468 A.

Prussia.

The Condition of the Royal Prussian Railway System for the Year 1900 (Die Etat der Königlich Preussischen Eisenbahnverwaltung für das Etatsjahr 1900). A statement of the official administration of the system, with details of expenditures for operation, maintenance, etc. 5000 w. Stahl und Eisen—Feb. 1, 1900. No. 32641 D.

Transportation.

Our Railroads and Our Canals. George H. Daniels. Extracts from an address delivered before the Utica Chamber of Commerce. 1700 w. Ry & Engng Rev—Feb. 24, 1900. No. 32741.

Transportation Department of Railroads. Russell Harding. Describes the tonnage system in train service, and notes its benefits. 1700 w. Ry Age—Feb. 23, 1900. No. 32731.

MOTIVE POWER AND EQUIPMENT.

Bolsters.

Bolster Specifications and Tests. Some considerations in regard to the design of bolsters, and suggestions for testing. 900 w. Am Engr & R R Jour—Feb., 1900. No. 32268 C.

Box Cars.

Report of Committee on Typical Dimensions of Standard Box Cars. Ill. 3500 w. Cent Ry Club—Jan., 1900. No. 32735 C.

Brake Recorder.

An Automatic Recorder of Emergency Brake Applications. Illustrates and describes the invention of W. E. Symons, which is intended to register all emergency applications of the brake, but does not record service applications. 450 w. R R Gaz—Feb. 2, 1900. No. 32294.

Car Heating.

Car Heating in Germany, Austria and Switzerland. Illustrated description of the systems used. 2600 w. R R Car Jour—Feb., 1900. No. 32435.

Car Ventilation.

Ventilating Passenger Cars on the Pennsylvania. Illustrated description of the system used. 600 w. R R Gaz—Feb. 9, 1900. No. 32452.

Couplings.

Accidents to Railway Servants: Editorial discussion of the report of the Railway Couplings Commission. 2000 w. Engr, Lond—Jan. 26, 1900. No. 32374 A.

Report of the Railway Couplings Commission. Extracts from the report concerning accidents, the value of automatic couplings, etc. 4200 w. Ccl Guard—Jan. 26, 1900. No. 32367 A.

Draft Appliances.

Exhaust and Draft. Arrangements in Locomotives. Synopsis of review of the progress of the past ten years, made by C. H. Quereau. 900 w. Am Engr & R R Jour—Feb., 1900. No. 32276 C.

Driver Brakes.

Improvements in Locomotive Driver Brakes. Illustrates the driving-wheel brake-rigging on the new locomotives built for the Lake Shore & Mich. So. Ry. and discusses present practice. 1400 w. Am Engr & R R Jour—Feb., 1900. No. 32274 C.

Driving Wheels.

Cast Steel Driving Wheels. Illustrations of various designs and information concerning them. Am Engr & R R Jour—Feb., 1900. No. 32272 C.

Grates.

Grates for Coke Burning. Information from J. S. Turner concerning coke burning on locomotives. Ill. 900 w. Am Engr & R R Jour—Feb., 1900. No. 32271 C.

Journal Boxes.

Instruction in Care of Journal Boxes. Describes a model used in instructing the men on the New York Central & Hudson River R. R. 1200 w. Am Engr & R R Jour—Feb., 1900. No. 32277 C.

The Proper Care of Packing in Journal Boxes, and Its Important Relation to Successful Lubrication. Discussion of the subject by H. C. McCarty and others. Ill. 11200 w. Cent Ry Club—Jan., 1900. No. 32734 C.

Locomotives.

Compound Locomotive for the Western Railway of France. Illustrated description of this new type for a railway leading to Paris. 700 w. Engng—Feb. 2, 1900. No. 32462 A.

Consolidation Freight Locomotives. Illustrated description of one of twenty-five freight locomotives, recently completed for the Lake Shore & Mich. So. Ry. 800 w. Am Engr & R R Jour—Feb., 1900. No. 32269 C.

Cooke Consolidation Locomotive, L. & N. Ry. Illustrated description with dimensions. 900 w. Ry & Engng Rev—Feb. 3, 1900. No. 32389.

Express Passenger Engine, North-Eastern Railway. Illustration and dimensions. 700 w. Engr, Lond—Feb. 2, 1900. No. 32467 A.

Locomotives on Egyptian Railways. Information from the report of F. H. Trevithick concerning the American and English locomotives. 2000 w. Ind & Ir—Jan. 26, 1900. No. 32363 A.

Marine Boiler Locomotive, A., T. & S. F. Ry. Illustrates and describes the application of a Scotch marine boiler to a locomotive. The engine is on trial in switching service in the Topeka, Kan., yards. 1400 w. Ry & Engng Rev—Feb. 10, 1900. No. 32487.

The Adaptation of the Locomotive for Safe High Speed Travel, with Special Reference to the Proper Method of Balancing its Reciprocating Parts. William E. Lockwood. On the effects produced by counter-balancing the driving wheels. Also discussion. 4200 w. N. Y. R R Club—Dec. 21, 1899. No. 32255.

The Detailed Weights of a Locomotive Engine. Gives list of the actual weight of the various parts of a goods engine and tender, V 14 class. 1800 w. Engr, Lond—Feb. 9, 1900. No. 32575 A.

The Four-Cylinder Compound Locomotives of the Northern Railway of France. Illustrated description of the engines designed for special service on this road. 2200 w. Sci Am—Feb. 17, 1900. No. 32505.

The Locomotive—Recent Practice and

the Future. F. W. Dean. Extracts from a paper read before the New England Railroad Club. Review and critical discussion of features of recent design. 3200 w. R R Gaz—Feb. 16, 1900. No. 32513.

Twelve-Wheel Compound Chicago & Eastern Illinois Railroad. Illustration and description of the latest heavy freight locomotive of the named road. 600 w. R R Gaz—Feb. 23, 1900. No. 32704.

See Street and Electric Tramways.

Lubrication.

Lubrication. A topical discussion by H. B. Hodges, Gen. Charles Miller, A. M. Waitt, and many others. 1700 w. N. Y. R R Club—Jan. 18, 1900. No. 32738.

Milk Cars.

New Milk Cars, Lehigh Valley Ry. Illustrated description of improved refrigerator milk cars. 500 w. Ry & Engng Rev—Feb. 17, 1900. No. 32558.

Mine Locomotives.

See Mining and Metallurgy, Mining.

Pintsch Gas.

See Gas Engineering.

Staybolts.

Staybolt Progress. Willis C. Squire. A letter discussing the movement of the side sheets and firebox sheets relative to one another, due to differences of temperature, and suggesting a line of investigation. Ill. 1200 w. Am Engr & R R Jour—Feb., 1900. No. 32275 C.

Tenders.

Locomotive Tenders. William Forsyth. A discussion of the tenders on English and American locomotives, and the improvements made in modern American designs. 2200 w. Am Engr & R R Jour—Feb., 1900. No. 32273 C.

NEW PROJECTS.

Africa.

The Railways of Africa (Die Eisenbahnen in Afrika). H. Claus. An excellent review of existing and proposed railways, classified according to political conditions, accompanied by a very good map. 3500 w. Glaser's Annalen—Jan. 15, 1900. No. 32643 D.

India.

Indian Railway Prospects. Notes the new schemes under the several railway systems, with histories of some of the more important. 8500 w. Ind & East Engr—Jan., 1900. Serial. 1st part. No. 32508 D.

PERMANENT WAY AND FIXTURES.

Compressed Air.

The Use of Compressed Air in the Freight Yard of the Lake Shore and Michigan Southern Ry. at West Seneca, N. Y. Illustrated description of this plant, and the uses to which it is applied. 3300 w. R R Car Jour—Feb., 1900. No. 32434.

Fastenings.

The Consolidation of Fastenings in Railway Cross Ties (La Consolidation des Attaches dans les Traverses de Chemins de Fer). M. Cartaull. A description of the Collet system, in which a trenail is screwed into a hole tapped into the cross-tie, the rail bolt then being screwed into the trenail. Used on the Paris, Lyons, and Mediterranean Railway. 2500 w. Rev Gen de Chemins de Fer—Feb., 1900. No. 32647 F.

Grades.

The Theory of Velocity Grades. Letters from Charles C. Wentworth, and C. Frank Allen, in further discussion of this subject. 2200 w. R R Gaz—Feb. 16, 1900. No. 32511.

Rails.

The Wear of Rails (Schienenverschleiss). K. Beyer. A discussion of a graphical method of determining the relative wear of rails of various sections. 1500 w. Scheweizerische Bauzeitung—Jan. 20, 1900. No. 32638 B.

Railway Shops.

Extension of the new Workshops of the Northern Railway of France (Agrandissements des Nouveaux Ateliers de la Compagnie des Chemin de Fer du Nord). A very full account of the locomotive works at Hellemes-Lille, with plans showing construction of buildings and arrangement of tools. Serial. Part I. 4 plates. 7000 w. Rev Gen de Chemins de Fer—Feb., 1900. No. 32648 F.

The Depew Shops of the New York Central. Illustrated description of some special devices in use and features of locomotive practice. 2000 w. R R Gaz—Feb. 16, 1900. No. 32514.

The Operation of the Hungarian Railway Workshops in 1897 (Erzebnisse des Werkstättendienstes der Königlich Ungarischen Staatsbahnen im Betriebsjahre, 1897). Rudolf Nagel. With tabulated statements of results, expenditures, and general details of operation. 4000 w. Glaser's Annalen—Feb. 1, 1900. No. 32645 D.

Signal.

The Lartigue and Forest "Crocodile" (Le "Crocodile" Lartigue & Forest). M. Cossmann. Describing the electric warning signal used on the Northern Railway of France. An electric contact of a brush on the locomotive with a shoe on the track operates a pneumatic whistle when a block signal is closed. 3500 w. Rev Gen de Chemins de Fer—Feb., 1900. No. 32646 F.

Station.

New Texas & Pacific Passenger Station at Ft. Worth, Tex. Illustrated description of this recently completed station. 600 w. Ry & Engng Rev—Feb. 3, 1900. No. 32390.

New Union Station at Dayton, O. Description, with illustrations, of a new union passenger station. 1100 w. R R Gaz—Feb. 23, 1900. No. 32707.

See Architectural Engineering, Heating and Ventilation.

Transcontinental.

American Transcontinental Lines. James Douglas. A sketch of the history, geography and topography of these railways. 15300 w. Trans Am Inst of Min Engs—Sept., 1899. No. 32543 D.

Transition Curves.

The Railroad Spiral. Editorial review of the condition of the transition curve problem, suggested by a paper by E. S. M. Lovelace. 1800 w. R R Gaz—Feb. 9, 1900. No. 32453.

STREET AND ELECTRIC TRAMWAYS

STREET AND ELECTRIC TRAMWAYS.

Bridge Crossings.

Trolley Wires Over Movable Bridges. Illustrated description of the arrangements on the North bridge at Hull, England. 600 w. Elec Eng, Lond—Feb. 9, 1900. No. 32591 A.

Cars.

Street Car Building. Charles Henry Davis. Illustrated detailed description of Stephenson practice. 800 w. St Ry Jour—Feb. 3, 1900. Serial. 1st part. No. 32330 D.

Claim Department.

The Organization of a Claim Department. J. W. Uppercu. Experiences and suggestions concerning this branch of street-railway service. 3000 w. St Ry Jour—Feb. 3, 1900. No. 32327 D.

Combination.

A Combination Steam and Electric Railway in Illinois. An illustrated account of the Peoria and Pekin Terminal Ry., which combines a street railway, an interurban electric railway and a steam railroad, all using the same tracks in common. 5200 w. St Ry Jour—Feb. 3, 1900. No. 32329 D.

Conduit Roads.

Electric Conduit Roads. Alton D. Adams. Briefly reviews surface-contact systems, third-rail, and electric conduit roads, explaining their operation and advantages and disadvantages. 2300 w. Munic Engng—Feb., 1900. No. 32385 C.

Detroit, Mich.

New Equipment for the Rapid Railway of Detroit. Illustrated description of this improved line, which carries not only passengers, but freight and express matter, and also provides electric light and power in the cities, towns and residences on the route. 2500 w. St Ry Jour—Feb. 3, 1900. No. 32326 D.

Double-Current.

The Metropolitan Railway Company, Toronto, Ontario, and Its Double-Current System. Illustrates and describes the recent improvements and extensions. 1600 w. Am Elect'n—Feb., 1900. No. 32286.

Electric Traverser.

An Electric Traverser for Railway Carriages. M. Sabouret. From *Revue Général des Chemins de Fer.* Illustrates and describes interesting apparatus for carrying railway carriages from one line of metals across to adjoining rails, at the Orleans Railway Station at Paris. 500 w. Elec Eng, Lond—Feb. 9, 1900. No. 32592 A.

Electrolysis.

Cure of Electrolysis by Independent Returns. C. A. Newbaker. A discussion of the electrical conditions that cause dangerous electrolysis and the best means to favorably alter these conditions. 4000 w. Am Elect'n—Feb., 1900. No. 32287.

The Electrolysis Problem in Chicago. Edward B. Ellicott. Describes the conditions, giving illustrations, and discusses the cause of the troubles, and the remedy. 1800 w. W Elect'n—Feb. 10, 1900. No. 32454.

Elevated Railway.

Proposed Electrical Equipment of the Berlin Stadtbahn. From the *Elektrotechnische Zeitschrift.* Details of a proposal for the electrical equipment of the Berlin elevated railway, indorsing the multiple unit method. Also editorial. Ill. 9500 w. St Ry Jour—Feb. 3, 1900. No. 32328 D.

Exposition.

Electric Transport at the Exposition of 1900 (Les Transports Electriques de l'Exposition de 1900). Emile Dieudonné. With a plan of the routes of the traveling platform, and the electric tramway, and plan and elevation of the trains for the latter. 1800 w. Revue Technique—Jan. 25, 1900. No. 32608 D.

Extension.

Recent Extension of the Bergen County Traction Company. Illustrated description of an extension containing a number of structural difficulties, and requiring trestles, viaducts and bridges. 1600 w. St Ry Jour—Feb. 3, 1900. No. 32325 D.

Goods Service.

Light Railway Goods. Service at Newburgh. An illustrated account of the methods employed by the Elec. Ry. Co. of Newburgh, N. Y. 1200 w. Tram & Ry Wld—Feb. 8, 1900. No. 32729 A.

Isle of Man.

A Water Power Tramway Plant in the Isle of Man. Illustrated description of a line 18 miles long worked solely by water power. 2000 w. Tram & Ry Wld—Feb. 8, 1900. No. 32728 A.

Isle of Man Electric Tramways: Water Power Utilization Plant. Illustrated description of the new turbine plant which has enabled the company to shut down their steam plant entirely and work their line solely by water power. 1200 w. Elect'n, Lond—Jan. 26, 1900. No. 32359 A.

Locomotive.

Modern Electric Locomotives (Moderne Elektrische Lokomotiven). A. Tischbein. A very comprehensive discussion of the present practice, including heavy locomotives, as well as those for shifting and local service, and for use in mining. Two articles, 7500 w. Glaser's Annalen—Jan. 15, Feb. 1, 1900. No. 32-642 each D.

Moscow.

The Electric Line of the First Street Railway Company of Moscow (Die Elektrischen Linien der Ersten Strassenbahn Gesellschaft in Moskau). Erich Krannhals. A general description of the plant, and views of points on the road and in the power house. 2000 w. Elektrotech Zeitschr—Feb. 8, 1900. No. 32659 B.

Motorman.

Some Notes on the Motorman as an Element in Street Railway Economy. Charles Hewitt. Reports experiments tried and the results. Also discussion. 1600 w. Pro Engs' Club of Phila—Feb., 1900. No. 32742 D.

Niagara Power.

The Application of Niagara Power to the Work of the International Traction Company. Sketches briefly the development of the generating plant and the transmission line, and gives detailed description of the machinery of the traction system. Ill. 3800 w. St Ry Jour—Feb. 3, 1900. No. 32323 D.

Philadelphia.

The Electrical Equipment of the Union Traction Company, Philadelphia. An account of some of the interesting features of the latest electrical practice, in the operation of the largest street railroad property in the world. Ill. 1700 w. Elec Rev, N. Y.—Feb. 7, 1900. No. 32394.

Power Plant.

See Electrical Engineering, Generating Stations.

Rail Welding.

See Electrical Engineering, Heating and Welding.

Rapid Transit.

An Important German Rapid Transit Problem. Concerning an experimental electric train built for the Wannseebahn. 1500 w. St Ry Jour—Feb. 3, 1900. No. 32331 D.

The New York Rapid Transit Tunnel. Illustrates the main features of construction in the proposed work, with map showing route, and gives an account of the undertaking. 1100 w. Sci Am—Feb. 3, 1900. No. 32266.

Single Rail.

The Single-Rail Suspended Railway Between Barmen, Elberfeld, and Vohwinkel (Die Einschienige Schwebebahn-Barmen-Elberfeld-Vohwinkel). A general description of this unique overhead electric railway, with an effective view of a portion of the completed work. 1800 w. 1 plate. Zeitschr d Ver Deutscher Ing—Jan. 27, 1900. No. 32619 D.

Snow Plow.

A Four-Motor Snow Plow. Joseph H. Smith. Illustrated description of a powerful plow built for the Interstate Consolidated St. Ry. Co., of North Attleborough, Mass. 1000 w. St Ry Rev—Feb. 15, 1900. No. 32509 C.

Toledo.

Toledo Traction Company. Burcham Harding. Illustrates and describes the plant of this company, which furnishes light and power on an extensive scale. 3800 w. St Ry Jour—Feb. 3, 1900. No. 32324 D.

Triest.

The Electric Plant of the City of Triest (Das Elektricitätswerk der Stadt Triest). G. Szuk. With plan and elevation of the building, and views in the engine and boiler rooms; also diagram of the switchboard, and map of the city, showing the primary and secondary distribution and the location of transformers. 2000 w. Elektrotech Zeitschr—Feb. 1, 1900. No. 32658 B.

Underground.

The Metropolitan Railway in Paris. Historical account and illustrated description of the construction. 4000 w. Engr, Lond—Jan. 26, 1900. No. 32372 A.

NEW CATALOGUES AND TRADE PUBLICATIONS

These catalogues may be had free of charge on application to the firms issuing them. Please mention The Engineering Magazine when you write.

Lea Manufacturing Company, Elwood, Ind., U. S. A.—Handsomely illustrated catalogue of enclosed-arc lamps, adapted for all circuits, and especially suited for the effective and economical lighting of workshops and manufacturing establishments.

B. F. Sturtevant Co., Boston, Mass., U. S. A.—Pamphlet catalogues (*a*) of Sturtevant generating sets, with automatic horizontal and upright engines; and (*b*) a description of the replacement of the brick chimney at the company's works by a system of mechanical draft.

The Westinghouse Machine Company, Pittsburg, Pa., U. S. A.—Beautifully illustrated pamphlet descriptive of the Westinghouse compound engine, with valuable data concerning tests of steam consumption, efficiency, and construction. Westinghouse direct-connected electrical generating sets are also noticed, as well as large engines for power house service; and the Westinghouse gas engine is illustrated.

The Fred W. Wolf Co., Chicago, Ill., U. S. A.—Ninth catalogue descriptive of the Linde refrigerating machines, including descriptions of numerous applications of artificial cooling. Details of brewery construction are also given, and numerous tables of valuable information in connection with the production and utilization of cold.

F. W. Gesswein, New York.—An elaborate catalogue of fine tools and supplies, bearing the title of "Worth Looking Into," published by F. W. Gesswein Co., New York. This catalogue was prepared by Mr. H. M. Crouse, and is a most excellent example of the modern tool and supply catalogue. The book contains 504 pages, with nearly 4,000 illustrations. Numerous tables of value for daily reference are also given. The subject of "files" is most elaborately treated, some 700 shapes being illustrated. The arrangement of the catalogue is highly convenient, and a very full subject index facilitates the finding of any tool illustrated or described in the book—and there are thousands of them.

Baldwin Locomotive Works, Philadelphia, Pa., U. S. A.—Record of Recent Construction, No. 8, containing illustrations and specifications of locomotives built for many railroads in the United States, as well as Mexico, Bengal and China. Recently constructed locomotives for mining, both steam and electric, are also shown. The specifications are in all cases given in English and French.

Warner & Swasey, Cleveland, Ohio, U. S. A.—General catalogue of machine tools for iron and brass work, including turret lathes of latest design, also screw machines, forming lathes, and milling machines. A number of useful tables are appended.

The Jeffrey Mfg. Co., Columbus, Ohio, U. S. A.—Illustrated catalogue of coal washing machinery, including also descriptions of retarding conveyors, steam coal tipple, elevating-conveying machinery, and coal mining machinery. Comparative tables of analyses of coal before and after washing are given, showing the improvement caused by washing.

M. C. Bullock Mfg. Co., Chicago, Ill., U. S. A.—Catalogue No. 40, devoted to the subject of portable hoists, with illustrations and specifications of self-contained steam hoists, adapted for delivery and erection complete. The designs include styles with either vertical or horizontal engines, with or without link motion.

Boston Belting Company, Boston, Mass., U. S. A.—Pamphlet catalogue of cotton and rubber garden-hose, couplings, nozzles, sprinklers, and reels. Various kinds of hose for different uses are listed, and a number of useful tools and appliances are shown.

Rochester Gas Engine Co., Rochester, N. Y., U. S. A.—Catalogue describing gasoline-vapor motors for use with launches and other boats. Details of motors, and of reversing gear are shown, together with a number of illustrations of boats of various sizes and kinds.

Lake Shore Engine Works, Marquette, Mich., U. S. A.—Illustrated catalogue of the "Superior" gasoline motors, as adapted to launches, yachts, and lifeboats. The motors are shown single, double, and triple cylinder; and reversible propellers, and reversible gearing are illustrated. A number of testimonials from users are appended.

The C & C Electric Company, New York—Pamphlet containing an alphabetical list of some purchasers of C & C multipolar generators and motors. Names from all parts of the United States are included, as well as those in England, Japan, and Mexico.

Charles Jacobs & Co., Boston, Mass., U. S. A.—Pamphlet describing the Jacobs patent water-tube feed-water heater, giving table of dimensions and capacities. The Lowden oil extractor and steam separator are also shown, and a list of promnent users of these appliances is given.

Stewart Heater Co., Buffalo, N. Y., U. S. A.—Pamphlets (*a*) giving price list and dimensions of bent tube feed water heaters, with illustrations showing both vertical and horizontal styles; (*b*) of double and single plunger pumps, adapted for feeding boilers or for other heavy service; (*c*) of the Otis tubular feed-water heaters, with price list, dimensions, and guarantee.

Buffalo Forge Company, Buffalo, N. Y., U. S. A.—Catalogue of Buffalo down-draft forges,

showing a variety of forges in which the smoke is removed as generated. Blowers for use with such forges are also shown, as well as an installation of a typical mechanical draft plant equipped with Buffalo induced-draft fans, economizers, stokers, etc.

Rife Hydraulic Engine Mfg. Co., New York.—Catalogue of the Rife hydraulic engine, being an improved form of hydraulic ram, in which impure water can be used to furnish the power for elevating pure water. Very complete directions for making surveys for the installation of such machines are given.

Brown & Sharpe Mfg. Co., Providence, Rhode Island, U. S. A.—Catalogue No. 102, containing illustrations of milling machines, grinding machines, automatic gear-cutting machines, screw machines, cutters, accurate test tools, and machinists' tools. This latest catalogue of the celebrated firm contains numerous additions, and will doubtless continue to hold its place as hitherto, in the working library of the engineer and machinist.

Fraser & Chalmers, Chicago, Ill., U. S. A.—Catalogue No. 46, 4th edition, describing the Reidler air and gas compressors and blowing engines. Many applications of compressed air are discussed, and a variety of machines, all using the mechanically-actuated valves of Professor Riedler's design, are illustrated and described. Much useful information and many valuable tables are included, and this catalogue should be examined by all having to do with compressed air.

Rockwell & Rupel Co., Chicago, Ill., U. S. A.—Catalogue of the Rockwell-Wabash expansion business-systems, including cabinet letter files, document cabinets, card index cabinets and material, and expansion bookcases. A great variety of useful office appliances is shown and explained, and much useful information concerning the applications of the card index is given.

Coatesville Boiler Works, Coatesville, Pa., U. S. A.—Neat pamphlet catalogue of modern high-duty return-tubular boilers; marine, vertical, and heating boilers; steel stacks, stand pipes, digesters, tanks, kettles, and other work in heavy sheet-iron and steel. Many illustrations of executed work are given, also specifications of boilers of various capacities and styles.

American Road Machine Company, Kennett Square, Pa., U. S. A.—Catalogue of rock crushers, elevators, screens, road machines, and appliances for use in road making. Road rollers, tractions, scrapers and sprinklers are also illustrated and described.

The American Well Works, Aurora, Ill., U. S. A.—"Encyclopedia" of information relating to all kinds of machinery for well-digging and boring, including also horse-powers, tractions, steam engines, gasoline motors, air compressors, boilers, pumps, windmills, and everything connected with the boring and operation of wells. The catalogue is well indexed and coded.

The Triumph Electric Co., Cincinnati, Ohio, U. S. A.—Catalogue of high-grade electrical machinery, generators and motors of excellent design and construction. A number of illustrations showing the applications of motors for the direct driving of printing machinery, machine tools and general machinery are given, and the construction of the generators and motors is shown in detail.

Dodge Manufacturing Company, Mishawaka, Indiana, U. S. A.—Large and handsome catalogue of the Dodge patent American system of rope transmission, with numerous illustrations of important installations in all parts of the United States. Applications of rope driving to nearly every possible requirement of transmission are given, and the advantages over shafting, belting, and gears, clearly shown.

Marine Iron Works, Chicago, Ill., U. S. A.—Pamphlet treatise on river navigation, with especial reference to shallow draught stern-wheel boats. Detailed designs of a number of boats are given, and instructions for information upon which estimates may be made.

M. C. Bullock Manufacturing Co., Chicago, Ill., U. S. A.—Catalogue No. 35, illustrating and describing the champion mine ventilator, showing the manner in which it is adapted for either blower or exhauster, or may be immediately converted from one to the other. Specifications of various sizes are given, and detailed instructions for erection.

Westinghouse Machine Company, Pittsburg, Pa., U. S. A.—Pamphlet entitled "A New Industrial Situation," setting forth the advantages of gas as a means of long-distance transmission of power, in connection with the Westinghouse gas engine. The prediction is made that the gas engine will gradually supplant the steam engine. A number of illustrations of gas driven electric plants are given, and the pamphlet is a model of typographical art.

The Goheen Manufacturing Co., Canton, Ohio, U. S. A.—Pamphlet discussing the preservation of wood, steel, and galvanized surfaces, and setting forth the advantages of the carbonizing coating made by the firm. The pamphlet contains an interesting comparison of the composition and behavior of a number of protective coatings.

The Toledo Machine and Tool Co., Toledo, Ohio, U. S. A.—Circular describing punching and stamping presses, beading and flanging machines, shears, dies, and other tools for the use of sheet-metal workers.

Hilles & Jones, Wilmington, Del., U. S. A.—Catalogue No. 6, a handsomely bound volume describing heavy machine tools, including punches, shears, riveting machines, plate planers, plate-bending rolls, and general machinery for sheet metal workers in heavy plate work and in structural work. Many machines are shown equipped with independent steam engines or electric motors, and all are handsomely illustrated.

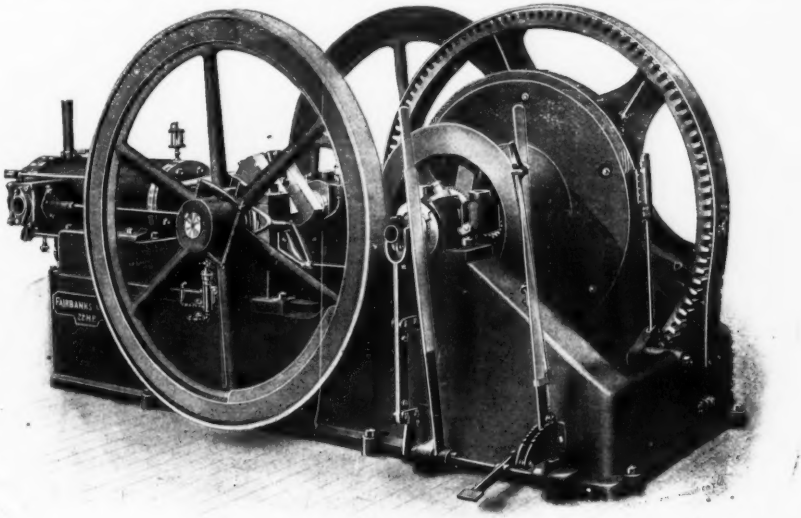
IMPROVED MACHINERY

New Processes and New Appliances

The matter here published is not paid for, nor can it be classed as advertising. But as the information is necessarily obtained from those who offer the appliances for sale, it is proper to say that the manufacturers, rather than ourselves, are responsible for the statements made.

Gasoline Engine and Hoister.

THE accompanying cut shows the general design and arrangement of a combined gasoline engine and geared hoister, manufactured by Fairbanks, Morse & Co., Chicago. The sizes range from 6 h.p. to 44 h.p. inclusive. The special advantage in using a gasoline or distillate driven hoist is that it entirely dispenses with the



difficulty often experienced in not being able to deliver solid fuel for a steam boiler. There is no water required, as there would be in the case of steam, and in cases where the water is bad and often impregnated with alkali and kindred chemical impurities that necessitate constant repair and expense in connection with the tubes and boiler shell, the use of the gasoline driven hoist is especially desirable. No special attendant is required, nor is a licensed engineer necessary. Anyone who could operate an ordinary hoist is capable of handling the gasoline machine.

The saving in cost, as compared with steam, is great, but it is difficult to give a comparison of the exact saving unless the locality at which the hoist was to be installed is known, as the comparative cost of fuel varies in different sections of the country. Where a shaft is being sunk at the end of a tunnel gasoline hoists are found most practicable when compared with any other class of power, as there is no loss, due to the fact that the hoist can be set in the tunnel and operate directly into the shaft, while with steam or elec-

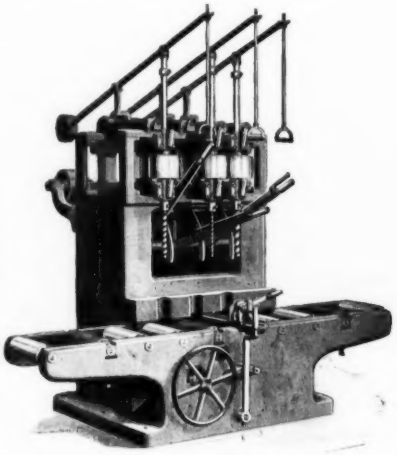
tricity it would be necessary to locate the boiler or the dynamo outside of the tunnel and convey the steam or electricity back into the tunnel to the point where it was to be used for hoisting. These machines are always ready to start at a moment's notice, and give out full power at once. There is no danger from them, as the firing of the charge is effected by an electric spark produced inside of the cylinder. These engines have a patent self-starting device which enables one man to start any size of hoist with ease.

Further particulars will be furnished by the makers to those requesting information.

Vertical Car-Boring Machine.

THE vertical car-boring machine illustrated herewith is a type of the heaviest three spindle vertical boring machine, and particular attention has been paid to the improvement of the driving or belt power of the boring spindles, thus improving the machine's capacity in boring large holes, and is especially adapted to use in railway repair and car shops, agricultural works, and wherever large boring is necessary. The boring spindles, three in number, are 1 7-16 inches in diameter, 8 x 6 inches driving pulleys, giving ample belt power. They run in gun-metal top bearings, with complete provision for oiling and at the extreme end of the spindles, thus preventing heating. They are counterweighted by adjustable weights and have adjustable handles for drawing the bit into the material. The spindle frames are mounted in "V" slides, carried in a frame-work on top of the column. The upper slides form an adjustable jib operated by a screw from the front side, giving a micrometer adjustment for taking up the wear. All idler pulleys on the spindle frame are fast to the shaft and mounted in capped bearings. The automatic belt tightener is supported in the same manner as the spindle slides, and is controlled by weight and bell crank. By this construction, the belt is relieved of all strain when the machine is stopped; and, when starting, the slack in the belt is taken up automatically.

The outside bearing spindles are adjustable to 45° inside and 60° outside, and are locked at any angle by the spring catch controlled by a handle convenient to the operator. They are mounted on a slide for traveling across the face of the timber, and are vertically adjustable to allow using short bits when swung to an angle. The cross movement is controlled by a



lever and segment gear. Automatic tighteners take up the belts when raising and lowering the outside spindle frames. These boring spindles are counterweighted by coil springs.

The table, as shown in the cut, consists of a heavy frame supporting 9 rolls, 5 inches in diameter, two of which are fluted and power driven, and is 9 feet 4 inches long. When desired, a traveling steel carriage of any length can be furnished. The necessary lever and clamping devices are supplied on the table for holding the material firmly in position.

The builders of this boring machine are J. A. Fay & Co., 271 to 291 West Front street, Cincinnati, O., who will furnish full information with regard to this or any other form of wood-working machinery.